POWER PLANT ENGINEERING

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Feed Water Treating and Purifying Plant

LARGEST TREATING PLANT EXCLUSIVELY FOR BOILER FEED WATER IN COUNTRY SUPPLIES FIVE WORKS OF REPUBLIC IRON & STEEL CO. BY S. H. McKEE

THE REPUBLIC IRON & STEEL CO. has five plants located along the Mahoning River, beginning with the Bessemer and Brown-Bonnell Plant, which is in the center of the City of Youngstown, Ohio, and ending with the By-Products Coke Works, located about 3 mi. down the river with the Tube Works, Open Hearth Works and Hazelton Blast Furnaces lying in between.

The question of good feed water for the boilers had been under consideration for some time, but it was not until the year 1916 that it was definitely decided to install a treating system. It was decided to use Mahoning River water as the source of raw water supply. It was also decided to locate the treating plant at the Open Hearth Works, which is just across the Mahoning River from Hazelton Furnaces and is centrally located with respect to the outlying plants. This location also had

FIG. 1. WATER TREATING PLANT OF THE REPUBLIC IRON & STEEL CO.

It was the intention to install a water softening and purification plant of sufficient capacity to satisfy the boiler feed requirements at these five plants not only for the conditions that existed at that time, but for any future extensions that might be made. The average boiler horsepower developed totals 50,500. The peak load runs to 78,000 boiler hp.

the advantage of being in the neighborhood of the unoccupied property of the Republic Iron & Steel Co., and any future extensions would be made on this property. Further, the greatest boiler generating capacity was concentrated in this locality.

The plant as installed has treating capacity of 300,000 gal. per hour and it is so laid out that a 25 per cent

extension can be made, to give an ultimate treating capacity of 375,000 gal. per hour, which will safely meet any future demands that might be made on this plant. The capacity of the plant, as installed, is very liberal, using the present requirements a basis, but it was felt that this was justified, particularly on account of its importance, in that the plants are dependent entirely upon this source of supply for a good and sufficient feed water for the boilers, although, as a safety measure, the feed water heaters are connected to the general service lines at the various works, this supply of raw water coming into action automatically if any serious stoppage in the supply of treated water should occur.

A two-compartment intake was built on the river bank, each compartment was provided with stationary and motor-driven traveling screens and with sluice gate valves operated from yard level, to enable each compartment of the intake to be cut off from river connection. Each compartment is of ample capacity to take care of the maximum ultimate requirements of the water softening plant. Concrete tunnels connecting each section of intake with a separate pump well under pump room in softening plant were built. These tunnels are of sufficient cross section to allow for proper cleaning, and a manhole is provided for ready access to tunnels that any accumulations may be easily removed.

The sewage from the city and wastes from all manufacturing plants above Youngstown, extending up as far as Warren, Ohio, are discharged into the river and the impurities thus introduced, in addition to the suspended matter and the hardened water in its normal condition, makes it an undesirable feed water supply without purification where high rates of evaporation are to be maintained.

It was decided to install a cold process system of the intermittent type to take care of the conditions, because of the demonstrated efficiency in treating Mahoning River water, as it was found that in this system, in which the treatment of the water is carried on in fixed volumes, the result was a water that is uniformly softened and at all times clear, regardless of the variations in the condition of the river.

The ground space occupied by this installation is 260 ft. long by 79 ft. wide,—the reaction and settling tanks occupying 166 by 79 ft. of this space and the operating and filter building occupying the remainder.

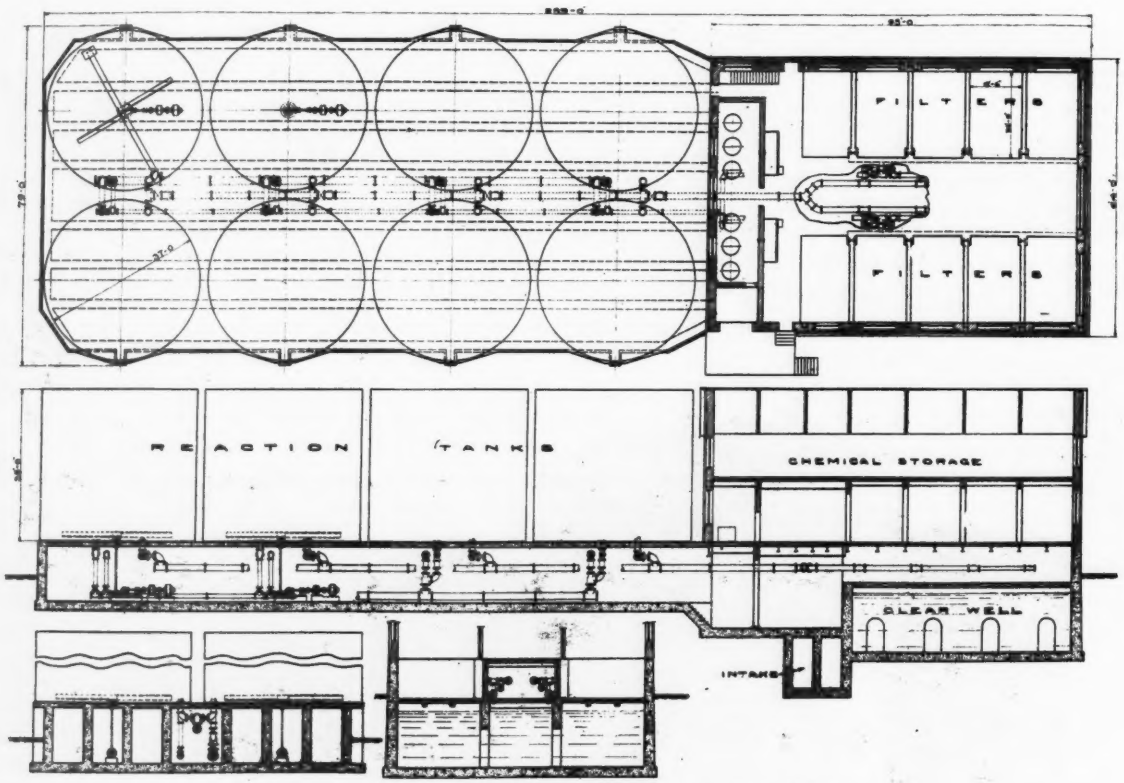


FIG. 2. PLAN AND ELEVATIONS OF WATER TREATING PLANT

The entire foundation is set 7½ ft. above yard level to guard against flood conditions, and the foundations for both building and tanks are thoroughly waterproofed to prevent leakage. There are eight reaction and settling tanks built of steel, 37 ft. in diameter by 35 ft. high, arranged in two parallel rows at 40 ft. centers with four tanks per row. Stairways and platforms are provided to allow ready access to the top of the tanks with tunnels and passageways in foundations underneath the tanks to house the filling and delivery piping and operating mechanisms, all being easily accessible for inspection and repair purposes.

Filtering Equipment

The pump room is located in the operating and filter house in the end of building towards reaction and set-

tling tanks. This building is 94 ft. long and 62 ft. wide, two stories high above foundation level. Below ground level at a distance of 12½ ft. is located the base of the pump room, which is 58 by 36 ft. In the end of building away from reaction and settling tanks, located below ground level, is the purified water basin or clear well, which is 58 by 52½ by 14 ft. deep, holding 295,000 gal. of water.

Over the clear well are the filter units, eight in number, 20 ft. long by 12½ ft. wide and 9¼ ft. deep, arranged in two rows of four each, between which is a pipe gallery 12 ft. wide with a headroom of 8 ft. 10 in., the floor of this gallery being at the same elevation as the bottom of the filters. The pipe gallery is floored over at the same elevation as the top of the filters. At the end of the filters and clear well this floor is extended across the basement, which contains the pumps. A portion of the floor immediately over the pump is cut out, to provide light and ventilation. This same floor level, or first floor, is the main operating floor of the purifying apparatus. On it are located the panels on which are mounted the control devices of the hydraulic valves and the alarm bells and switches for motors. There are also on this floor the recording gages, the sample line faucets and basins, the apparatus for testing the samples of water, and the valve stem extension stands for the operation of the filter valves. On this same floor level, or first floor, there is a separate dust-proof room, 42 ft long and 10 ft. wide by 14 ft. high, in which are installed six reagent mixing tanks. In this room the charges of reagents for treating the water are made up and from here delivered to the reaction and settling tanks.

The second floor of the pump and filter house is used for the storage of chemicals and for weighing out the charges required for treatment. This floor is reached by an elevator that has an outside entrance onto an unloading platform 3½ ft. above ground level and served by a standard gage railroad track.

Stairways are provided connecting all floors of the building, and the building proper is constructed with a steel frame, brick curtain walls and steel sash with reinforced concrete floors and with a concrete slab roof covered with built-up roofing, this construction resulting in a very attractive and well lighted building.

Settling Tanks

Inasmuch as the capacity of the treating apparatus was based on the operation of the settling tanks in pairs, each pair having a capacity to provide water at the rate of 300,000 gal, per hour for 1⅔ hr. on the basis that water is delivered for filling a pair of tanks in one hour, or at the rate of 500,000 gal. per hour, there were supplied to perform this service, two pumping units, each capable of delivering 10,000 gal. of water per minute against a 70-ft. head. Each unit consists of a horizontal single stage double suction centrifugal pump driven through reduction gears by a condensing steam turbine, and each unit is of ample size to meet the ultimate demands of future requirements.

It will be noted that there has been provided a dual installation of intake, tunnels, well, etc., to supply these pumps with the necessary water, and each system can be cut off at will and cleaned, as the remaining system is of ample size to take care of all requirements.

The raw water from the supply pumps is delivered to the reaction and settling tanks through a 20-in. main, from which 14-in. connections are made to each of the tanks.

These pipe connections are through the bottoms of the tanks. Each tank connection is provided with a branch, which is connected up with a sewer line. The valves in both the filling and the sewer connections are hydraulically operated, with an emergency shutoff valve between the hydraulic valve in the filling line and the water main. Any tank or pair of tanks can be isolated, if necessary.

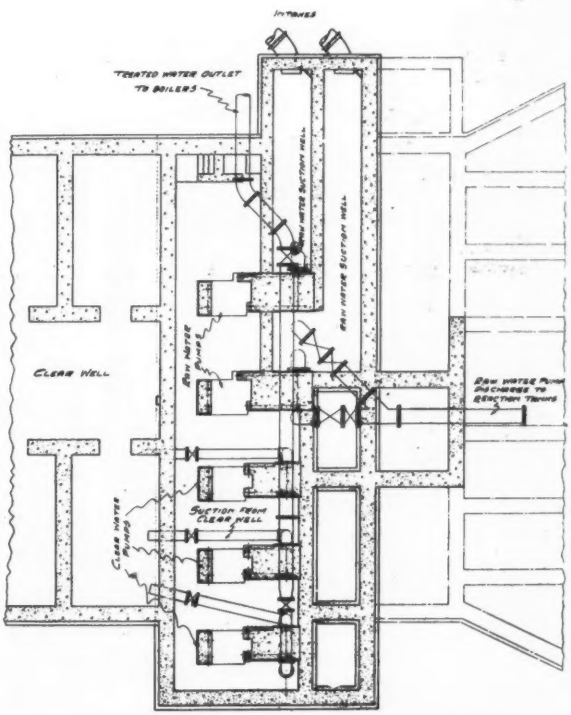


FIG. 3. ARRANGEMENT OF WATER COMPARTMENTS AND PIPING BELOW GROUND LEVEL

Each tank is equipped with a mechanical stirring device, operated by an individual direct-connected electric motor. The stirring device shafting passes up through the bottom of the tanks, through a stuffing box. Each tank is provided with two float-operated electric alarms with bells located in the operating house. Each tank is also equipped with a recording altitude gage, which registers the time required for filling a tank, the time the tank is settling and the time in which it is emptied, the time consumed in washing filters and amount of water so used, the charts of these gages giving an accurate record of the treatment cycle of each tank.

The water after being treated and settled is drawn from the tanks through a floating outlet pipe 14 in. in diameter that takes the water from the top and follows the descending level until a stop carried on the pipe rests on the bottom of the tank, holding the pipe at a fixed elevation to insure a uniform emptying depth and to avoid running sludge to the filters.

These floating outlet pipes are connected to the bottoms of the tanks through a special form of flanged elbow that permits the pipe to move in a vertical plane, but prevents movement in a horizontal plane, and are connected into an 18-in. main. Each connection is provided with an hydraulically operated valve and, in addition, there is an emergency shutoff valve between the main and the hydraulically operated valves. The

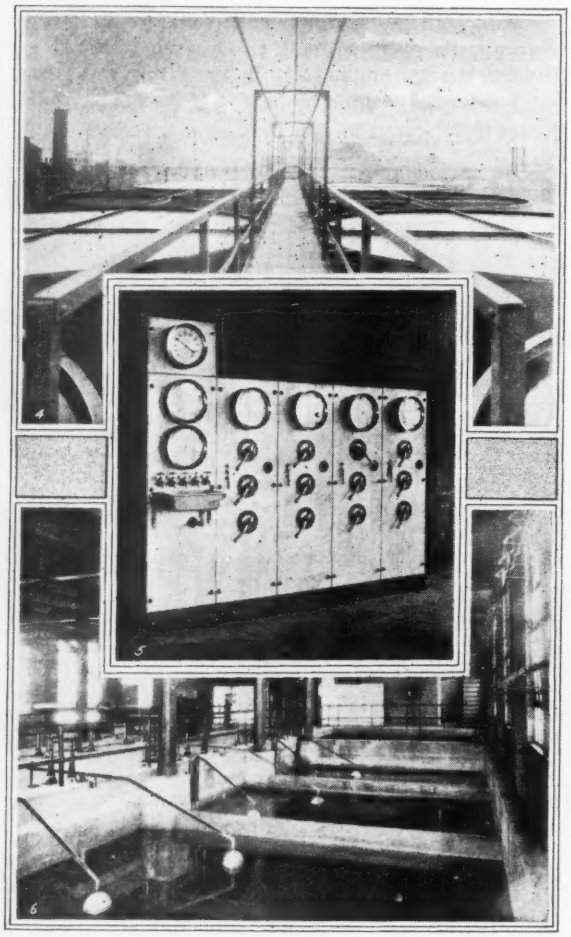


FIG. 4. TOP VIEW OF REACTION TANKS
FIG. 5. CONTROL BOARD FOR TREATING PLANT
FIG. 6. VIEW IN THE FILTERING ROOM

main is carried to the filters, where it is divided into two lines, each supplying four filter units.

Controlling Devices

THE CONTROLS, reagent mixing tanks, etc., are located in operating and filter house on operating floor. The controls for each reaction tank are mounted on individual marble panels and these different panels are assembled in two rows of four panels each, similar to a switchboard. Each panel has a recording altitude gage, three control handles connected to four-way cocks for inlet, sewer and outlet valves to and from reaction tanks, a push-button motor starter for stirring device and a switch for the high water alarm. At the end of each row of operating panels there is a panel fitted with a two-pen recording thermometer indicating temperature of the incoming and outgoing water, also an indicating pressure gage for the hydraulic system, a discharge line recorder and four sample bibs mounted over a sink. These sample bibs are connected with 1-in. lines to the different reaction tanks for drawing samples of the treated water for testing.

Pressure for operating all hydraulic valves is obtained from a pair of duplex steam pumps located in pump room of building, one of these pumps being a spare. The water lubricated by soap in solution is drawn from a sump, then forced by the pumps through a pneumatic water supply tank into a main from which connections are made to four-way cocks controlling the different hydraulically operated valves. The pressure used is 70 lb.

Mixing Tanks

SIX REAGENT mixing tanks are provided in two rows of three tanks each, so that three different reagents can be prepared simultaneously for making treatment in two reaction tanks at the same time. These reagent mixing tanks are fitted with motor-driven stirring devices with silent chain drive and friction clutches. The charges of reagents are weighed out on the storage floor and then dumped into hoppers which are hung through the floor. The hoppers have an outlet gate at the lower end, through which the chemicals are allowed to fall intc the reagent mixing tanks.

In the pump room under the reagent mixing tank room there are three centrifugal pumps for delivering reagent solutions to the reaction tanks. These three pumps are located and connected in such a way that the third pump is a spare for use with either row of reagent tanks.

Discharge piping from the reagent pumps is arranged so that each pump supplies for reaction tanks. The suction and discharge connections to the pumps are arranged so that the reagents from any one of the three reagent mixing tanks can be pumped to any of the four reaction tanks.

The delivery of water from the reaction and settling tanks to each filter is controlled by a double-disc balanced valve, operated with a float in the filter. The outlet from the filters is discharged into the purified water basin immediately under the filters and under the pipe gallery. This basin is equipped with an indicator to show water level and also equipped with a recording altitude gage to show the water level at any period of the day.

Arrangement of the pipe connections to the filter units is such that any or all of the filters can be operated with any or all of the reaction and settling tanks discharging water through the floating outlet pipes. The filters are equipped with special form of brass strainers screwed into a manifold, with the strainers uniformly distributed over the area of the filters, approximately 7½ in. center to center.

The filters are also equipped with an individual air-wash system consisting of ¾-in. brass laterals, iron pipe size, drilled for a uniform distribution of air. This air piping is placed immediately above the strainer piping in the filter bed. Air is supplied from a direct-connected motor-driven positive blower located in the pump room.

Treating Process

The charges of lime, ferrous sulphate and soda ash are weighed out and put into the reagent mixing tanks. The lime is slaked so as to be ready to be introduced into the reaction and settling tank when the filling of the tank begins. As soon as the filling of a reaction and settling tank begins the charge of lime is pumped into the tank and the stirring device in it is started. The stirring device is kept in operation during the entire period of filling the tank and no other reagents are introduced until the tank is full, the filling time being one hour. When the tank is full, the charge of ferrous sulphate is introduced and ten minutes afterward the sample of water for testing the correctness of the treatment with lime and ferrous sulphate is obtained.

Following the introduction and mixing of the ferrous sulphate the charge of soda ash is introduced and the stirring continued for 15 min. thereafter. The stirring device is then stopped and the water allowed to stand quiescent for reaction and settling; 30 min. after the stirring is stopped, a sample of the fully treated water is drawn for testing. At the end of the settling period, the water is delivered to the filters as required.

The floating outlet pipe is flushed into an empty tank before turning the water into the filters. This washes out the sludge that has accumulated in it and prevents the fouling of the filters.

The floating outlet pipe draws off the clearest water from the top of the settling tank and follows the drop of the water level. The precipitates settle out of the water ahead of the pipe, so that there is only a minimum of sludge carried to the filters. The stop on the pipe prevents it from reaching a position where settled sludge will be carried to the filters. The softened and settled water after passing through the filters is delivered into the clear well.

Rate of flow of the softened water from the settling tanks to the filters is controlled by the position of the water level in the clear well and with the clear well full the inlet valves on the filter automatically operate to hold back the water in the settling tank. The clear well acts as a balancing tank between the demand for water and the supply coming from the reaction and settling tanks. When the demand for the water exceeds the capacity of the equipment, extra water is supplied from the clear well.

The function of the filter is to remove the crystalline precipitate that is too fine to settle and to guard against the possibility of dirty water from the settling tanks from any cause getting into the boiler feed system. The equipment is designed to operate two reaction and settling tanks simultaneously and with the four pairs of tanks the alternate filling and emptying of a pair maintains a constant supply of water. The interval for settling, together with the volume of water held by the purified water basin, or clear well, gives sufficient time to treat correctly all of the water used.

Two pumps were installed to deliver treated water from clear well to the various plants, each capable of pumping 5000 gal. of water per minute, against a 145-ft. total head. Each unit consists of a horizontal single stage double suction centrifugal pump driven through reduction gears by a condensing steam turbine, and each unit has sufficient capacity to meet any future demands, although it was deemed advisable to provide room for the installation of an additional pumping unit.

Under average conditions it required a total head of 137 ft. to deliver the necessary quantity of water to the Bessemer and Brown-Bonnell Plant through the 16-in. pipe that was in place, but under peak conditions at this plant it requires a total head of 245 ft. to supply the necessary quantity of water. The maximum total head required to deliver the necessary quantity of water at the other plants was 127 ft. A pumping unit capable of delivering the quantity of water required at peak conditions of 245 ft. head at the Bessemer and Brown-Bonnell Plant would necessitate a two-stage centrifugal pump with a turbine of sufficient size to take care of this load. A careful investigation of the peak conditions over a considerable period of time disclosed that the maximum length of duration was 12 min.

The solution of this problem was to build a storage make-up tank of 20,000 gal. capacity, set adjacent to the feed water heaters at the Bessemer and Brown-Bonnell Plant and placed at a sufficient elevation to deliver water to feed heaters by gravity. It required a total head of 134 ft. to fill this tank, but, in order to be on the safe side, pumps were installed to work against 145-ft. head, using single stage centrifugal pumps. This tank is under control of a motor-operated valve set in the vertical supply line, which is controlled by the pressure under the valve; should this pressure drop, due to the occurrence of peak conditions, the motor automatically opens valve and the necessary make-up water held in storage is supplied the feed heaters. This valve remains open until such a time as the water requirements decrease and the tank is filled, when the valve is automatically closed by the building up of pressure in the supply line.

MAHONING RIVER WATER—RAW AND TREATED

Grains per U. S. Gallon.

	Raw	Treated	Raw	Treated	Raw	Treated
Volatile & Org. Matter	1.15	.65	.95	.75	1.05	.65
Silica	.45	.45	.75	.75	.75	.45
Oxides of Iron & Alum.	trace	trace	trace	trace	trace	trace
Calcium Carbonate	2.43	.86	2.80	.60	3.20	.80
Calcium Sulphate	11.32	---	5.03	---	3.94	---
Magnesium Sulphate	4.86	---	3.84	---	2.86	---
Magnesium Hydroxide	---	.48	---	.17	---	.25
Sodium Carbonate	---	2.78	---	2.12	---	2.00
Sodium Sulphate	.53	18.46	4.40	15.05	.85	8.95
Sodium Chloride	9.40	10.22	2.45	2.57	2.22	2.54
Sodium Nitrate	---	---	trace	trace	.17	.17
Sodium Hydroxide	---	.94	---	1.86	---	.64
Manganese Carbonate	.08	---	---	---	---	---
TOTAL SOLIDS	30.22	34.86	20.22	25.37	15.11	15.25
Suspended Matter	.65	trace	.45	filtered out	1.45	trace
Free Carbonic Acid	.25	none	none	none	.25	none
INCRUSTING SOLIDS	19.14	1.81	12.42	1.52	10.82	1.48
NON-CRUSTING SOLIDS	9.93	32.40	6.85	21.10	3.24	14.10

The supply and delivery pumps are steam-turbine-driven, and in connection with these units a water works type of condenser was installed in the pump pit of the water softening building proper. The treated water is used for condensing purposes, as there was a much larger quantity at all times than necessary for this purpose and it was a very simple matter to pass the water through the condenser on its way to being delivered to the various plants. A bypass is provided for passing the treated water around the condenser, should this become necessary. A master Venturi meter for check purposes is provided in the main delivery line just outside of the water softening building proper.

Analyses of the Mahoning River water before softening and purification are here shown with analyses of the

water after being softened. In these softened water analyses you will note the absence of the sulphate, chlorides, and nitrates of lime, iron and magnesia, also that the total of the residual lime as calcium carbonate and the residual magnesia as magnesium hydroxide is less than 2 grains per gallon. In addition to the reduction in incrusting solids, the water is free from suspended matter, the turbidity being zero.

With this equipment it is possible to control the treatment of the water and to keep it within any desired limits. There is a striking contrast in the appearance of the water before being softened and purified and the water as delivered into the clear well, and the system is giving the anticipated results.—Abstract of paper read before the Engineers' Society of Western Pennsylvania.

Why Is a Fireman?

By G. H. Wallace

"MAKING of a Fireman," is a subject which cannot be disposed of easily in a single article, or several of them, nor even in a single volume of liberal proportions. Like most occupations, the task might appear an easy one, and in a way, it is—but in order to be a *real* fireman one must devote the same thought and study to it as one would to attain the same degree of perfection in law, medicine or the pulpit.

Every reader can call to mind many examples of small caliber lawyers, the back number country (and city) practitioners, and those of the cloth whose fitness for their profession lies wholly in a willing disposition rather than in adequate qualifications.

Just so with a fireman. To begin with, how many men feel that they are "called" to be firemen?—or any other trade for that matter? How many of you who read this formed your ideal while young and said to yourself, "Now when I get to be a man, I'm going to be a fireman!" Very few.

The positions we occupy in our everyday life are to a certain extent a matter of circumstances. Let me illustrate. At a certain plant was a young man running an assortment of wood working machinery. When the regular fireman was off for a day or so, this young fellow, Bill we will call him, was called in to "Keep 'er hot." The task was comparatively an easy one, and he had no difficulty in fulfilling our most sincere hopes.

But there came a time when the regular fireman took more than one day to sober up on, and this with a growing disposition on his part to let the little things "slip" brought us to the point where patience ceased to be a virtue,—and he was let go.

"Bill, will you take the job for a few days till we get the right kind of a man?" "Oh—y-e-s, I suppose so, but I don't know anything about it; I'm a wood worker." Well, Bill stayed. There were any number of applicants for the job (as there usually are) but none seemed to be the right man.

In a week or so, Bill appeared more at ease. He was coached a little here and there and with a little help from "the old man" cleaned the valves, inside and out. He had been shown how to cut and lap the packing rings on the pump pistons and other little things.

And then one day, "Bill, I don't think we need to look for a fireman; we've got one right here on the job, Suppose you stick?" Bill leaned up against the heater with one foot on the scoop and with a glance at the gage said: "D'yu suppose I'd ever make a fireman? It's all I k'n do to know which end of the boiler to fire at. I ain't never had no 'sperience only what I've had here."

"Bill, you've got the main features about you to make a fireman, a willing disposition to work and willingness to learn. With these, you will make a good fireman and, let us hope, a good engineer, some day."

So Bill stayed. When he found that he was the whole sandwich and not the lettuce leaf filling between two other firemen—one gone and one coming—he began to take quite an interest in the job.

The first thing he did was to turn the hose on the inside of the boiler room and wash the walls and windows from the ceiling down. Then he polished up the gages and other brass work and swept up the floor. "Now it begins to look better," he said.

With this good start, Bill began to use his head and to ask questions. For several days, he was observed between fires closely studying the boiler feed pump, a 6 by 4 by 6 in. good old-fashioned steam eating duplex.

"What's on your mind, Bill?" "Well, sir," replied Bill as he shifted from one foot to the other, "I can't see why that pump takes steam from the boilers and pumps water into the same boilers. There's the same pressure at both ends, ain't there?"

"Yes, there is. But doesn't that name plate suggest something to you?" "Yes, it says 6x4x6; but what are the 6's and the 4 for?"

"Well, Bill, that means that the steam pistons are 6 in. in diameter and the water pistons are 4 and that the length of the stroke is also 6 in."

"Well?"

"The area of a 6-in. piston is 28.27 sq. in. and the area of a 4-in. piston is 12.56 in. Now, Bill, if your boiler carries, say, 100 lb. of steam, you will have (disregarding friction, etc.), about 2800 lb. pressure on the steam end of the pump and only about 1250 lb. on the water end to resist it—so the water has got to go somewhere and the only place is into the same boiler that the steam comes out of. Do you get it, Bill?"

"Why, sure! Why didn't I think of that before?"

"And, Bill, there are lots of things about firing to think about and when a fellow gets into the habit of thinking he is started in the right direction to make something useful of himself; when he gets into the habit of sleeping between fires and letting his brain factory run down, he is just as surely headed in the right direction to make something useless of himself. Am I right, Bill?"

"You are."

U. S. Civil Service Commission announces an examination, Aug. 26, for metallurgist, for men only. A vacancy in the Bureau of Mines, Department of the Interior, Pittsburgh, Pa., at $2700 a year, and vacancies in positions requiring similar qualifications, at this or higher or lower salaries, will be filled from this examination. Competitors will be rated on education and experience, publications, and reports, or thesis. Applicants must not have reached their forty-fifth birthday on the date of examination. Apply for Form 2118.

FUEL CONSERVATION LETTERS

By Joseph Harrington, Formerly Administrative Engineer for the State of Illinois

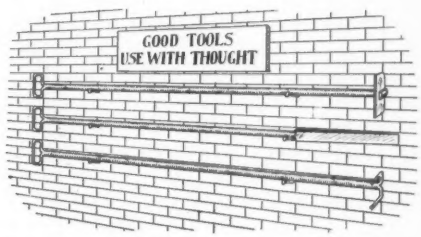
Fuel Bed Disturbance and Clinker Formation. Letter No. 15

EVERY fireman and engineer operating a hand fired boiler plant knows what a clinker is, but may not fully appreciate how to avoid forming clinkers nor the influence they have on the plant efficiency. A clinker is nothing more nor less than ash which has been melted and run together to form a large body or mass of material in the fire.

How clinker may be avoided is apparent when you stop to consider how clinker is formed. The underside of the fuel bed is where ash naturally forms, and if the fuel bed is not disturbed this ash then underlies the hot part of the fuel bed and is in a place where the temperature is not sufficient to melt it. The first thing, therefore, is to let the ash stay below the fire. Keep your slice bar out of the fire all you possibly can, and also quit raking it. Fill up the thin spots with a shovel and you will get far better results.

A layer of coal will usually burn down into a layer of ash which is fairly porous; and if not disturbed, air will pass through it in sufficient quantity for your combustion requirements. Every clinker is more or less air tight and you not only overheat the grate bars below the clinker, but prevent the fuel burning out on top the moment you slice it.

Without doubt, the shaking grate has the effect of keeping the ash layer opened up for the passage of air without kicking it up into the fire. A dumping grate violently shaken may have just the opposite effect.



In mechanical stoking, this matter must also be given consideration, especially when the fuels burned are those which contain a considerable percentage of ash or sulphur and have a tendency to fuse at low temperatures. To the prospective buyer this question should be considered as basic, and the most careful thought given to the question of whether the proposed stoker does or does not invert the fuel bed.

When the hand-fired furnace has to be sliced or a clinker removed from the side wall, any part of the clinker which is loosened should be hooked out of the fire with as little disturbance as possible before it has a chance to melt down and form one twice its size.

Ash melts at varying temperatures or somewhere between 1950 and 2600 deg. F. The actual temperature in a fuel bed which is active will invariably be more than even the maximum temperature mentioned; so that it is almost inevitable that melting will occur if ash is exposed to the full effect of the fuel temperature.

In mechanical stoking, however, there are certain conditions under which clinkers form more readily than others. It is a fact familiar to stoker operators that these machines can be operated up to a certain rating without serious clinker trouble; but when the furnace is forced beyond that point, clinker forms. There is, therefore, a sort of critical rating resulting in a certain temperature beyond which it is not possible to go without trouble. As a rule, the formation of bad clinker is such a serious detriment that it involves a loss greater than using another boiler and operating all at a somewhat lower rating.

The steam flow meter and coal scale, as well as the draft gage, should be watched to determine the conditions which obtain at this critical point. Then when this is definitely decided, the setting should be put under inspection and studied with reference to its influence on the furnace temperature. Too much surrounding brickwork will cause excessive temperature and this will be reached before the boiler is anything like up to its capacity.

Remember that the intensely hot gases arising from the fuel bed must get out of the furnace. If the boiler shell or the front bank of tubes is directly in view of the fire, so much the better; because they will then receive and absorb the radiant heat emanating from the fixed carbon of the fuel bed, and keep the furnace temperature down an appreciable amount. For proper flow of the furnace gases, the actual exit should as a rule be one-third of the grate surface.

If the heat is absorbed as fast as it is made, a condition of equilibrium will result and the temperature will remain constant and normal; but if heat is produced faster than absorbed, then destruction of the furnace side walls, grate bars and surrounding parts immediately results.

To sum up, therefore, let us avoid clinker formation by all practical means; and these means consist in absence of fuel bed disturbance and a design of the furnace which prevents the development of excessive furnace temperature.

Vacuum---I

TECHNICALITIES OF VACUUM CREATION IN POWER PLANT PRACTICE. BY ROGER TAYLOR

MANY POWER plant engineers, particularly in the larger plants, are undoubtedly familiar with the necessity of maintaining the highest possible vacuum. There are, however, engineers operating in both large and small plants, who fail to appreciate the importance of this question, not realizing to the fullest extent the bearing it may have upon the efficiency of the unit, and ultimately upon the coal consumed.

Within recent years very rapid developments have taken place in the turbine field. There has been a large increase in the size of units and the efficiency has been materially improved. As a result, greater steam pressures and higher temperatures of the steam by superheating have been employed. This has had the effect of increasing the heat supplied to the turbine, but a large part of the increase in the efficiency is undoubtedly due to the improvement made in the condensing apparatus, whereby much higher vacuums have been attained, with a consequent reduction in the heat contents of the steam at the exhaust pressure. This latter, which is the heat rejected and given up to the circulating water of the condenser, represents by far the greater part of the heat loss of the plant. The tendency has been to increase the temperature range of the steam between admission and exhaust, for with a given heat input, the more this range is increased, the greater becomes the efficiency and it is obviously necessary to maintain the exhaust pressure, and, therefore, its heat contents as low as possible.

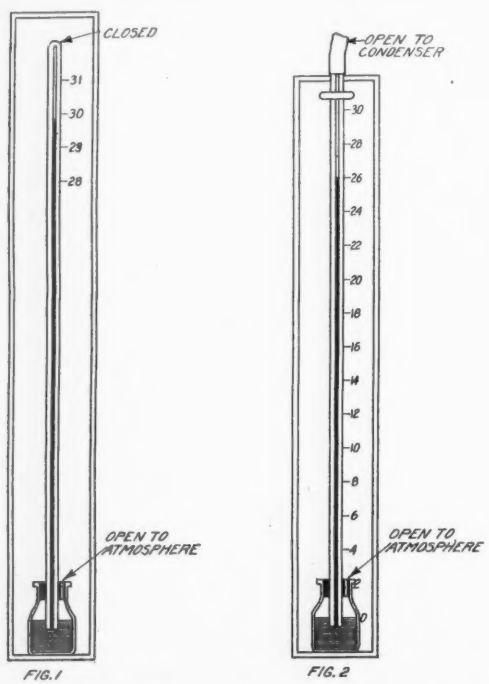


FIG. 1. MERCURY TYPE BAROMETER
FIG. 2. MERCURY COLUMN VACUUM GAGE

Just as strong an effort should be made by the turbine attendant to maintain the exhaust pressure and temperature at the lowest possible point, as is expected of, and is usually made by, the fireroom force to maintain the boiler steam pressure at its correct point. When it is realized that the effect of a drop in vacuum of ½ in. below the value that should be carried upon the steam consumption of the unit is much more pronounced than a drop of 10 lb. in boiler pressure, the desirability of making a constant effort to maintain the vacuum at the proper point will be readily seen.

Following the improvement in turbine installations and the higher efficiencies obtained by the use of higher vacuum, it has, of course, been necessary that considerable improvement and refinement be made on the auxiliary apparatus for the condensers in order to obtain this higher vacuum and quite naturally the operation of this apparatus demands close attention and study in order to attain and maintain the desired results.

ECONOMICAL LIMIT TO VACUUM

IT IS generally recognized that with reciprocating engines, there is a limit to the extent to which the absolute back pressure can be reduced, or the amount of vacuum that it is economical to use due to rapid increase in the steam volume when expanded to the lower pressures. With a large number of expansions, the low-pressure cylinder would necessarily have to be of an excessive volume, if the attempt were made to carry very low absolute back pressures. In addition to this, the condensation losses are materially increased due to the rapid decrease in steam temperatures as the vacuum increases.

Also while it is possible that the vacuum within the condenser may be high, there is usually a decided drop between the condenser and cylinder, due to the restricted steam areas. Conditions such as the steam pressure, cylinder ratios, cutoff point, number of cylinders, etc., will govern just what the most economical vacuum will be for any particular installation, and while there is no doubt that a reduction in the absolute back pressure by the vacuum will tend to give a material gain in economy due regard must be given to a number of factors which will have limiting effects upon the vacuum to be carried upon the reciprocating engine.

These limiting factors do not apply in the case of the steam turbine. The steam may be expanded within the turbine to a pressure very close to that of the condenser, and the lower this pressure is carried the greater will be the relative gain in economy. This type of prime mover being essentially a velocity motor, utilizes the available heat of the steam, in increasing the velocity or kinetic energy of a jet of steam, by expanding through suitable nozzles, then transforming this kinetic energy into mechanical work by the imparting of this velocity of the revolving buckets. The steam flow being continuous makes this type of prime mover well adapted to use the steam at the large volumes corresponding to the low pressures, in that it is possible so to design the various parts, nozzles, blades and wheels, that constant conditions as to pressure and temperatures exist in them at any

given load. The fluctuating temperatures are absent that exist in the reciprocating engine cylinder so that the condensation from this cause is removed, all condensation being the result in the turbine of the adiabatic expansion of the steam.

Measurement of Vacuum

Any space under a lower tension or pressure than that of the atmosphere is commonly said to be under a vacuum. This vacuum is indicated by a gage, the reading of the gage showing the amount of the atmospheric pressure that has been removed from the space to which the gage is connected. The gage may be calibrated to read in inches of mercury or indicate directly the pounds pressure. The difference between the reading of the vacuum gage and the pressure of the atmosphere at that particular time and place is the amount of the atmospheric pressure remaining within the space to form the back pressure or absolute pressure against which the engine must exhaust. Assume that the pressure of the atmosphere is 14.73 lb. corresponding to a barometer reading of 30 in. mercury, and that the reading of a vacuum gage gives 28 in., 1 in. of mercury exerts a pressure of 0.491 lb. at its base, so that $28 \times 0.491 = 13.75$ lb. is the amount of the pressure removed from the space to which the vacuum gage is connected and the difference between 14.73 lb. and 13.75 lb. $= 0.98$ lb. is the absolute pressure remaining, or the back pressure against which the engine must exhaust, similarly with 26 in. indicated vacuum and the same atmospheric pressure 14.73 lb. then $26 \times 0.491 = 12.76$ lb. is removed and $14.73 - 12.76 = 1.97$ lb. is the back pressure in this case. Thus, subtracting from the atmospheric pressure the vacuum reading reduced to lb. pressure gives as a result the absolute back pressure.

The atmospheric pressure at sea level is 14.7 lb.; at higher altitudes than the sea level the pressure is reduced. In addition to this effect of altitude the atmospheric pressure is influenced by other conditions, and at any particular place there may be quite a fluctuation daily in the atmospheric pressure. In order to obtain the true pressure an instrument known as the barometer is used, which, as in the case of the vacuum gage, may be in the form of a mercury column. Essentially there is very little difference beeween the mercury column as used for a vacuum indicator and the barometer, both consisting of a glass tube with the lower end submerged in a body of mercury in a suitable receptacle; with this difference, however, in the barometer, Fig. 1, the upper end of tube is sealed, all the air is exhausted from the tube, with practically a perfect vacuum above the surface of the mercury in the tube and the atmospheric pressure is exerted on the mercury in the container.

Due to the unbalanced pressures on the two surfaces of the mercury, it will rise to a height in the tube proportional to this difference in pressure or the atmospheric pressure with the mercury column used as a vacuum gage.

In Fig. 2 the upper end of the tube is open and connected to whatever space it is required to measure the vacuum. Again, this is also a case of unbalanced pressures upon the two surfaces of the mercury, the atmospheric pressure being upon the surface of the mercury in the container outside of the tube and the pressure on the mercury within the tube being that of the absolute pressure remaining within the condenser. The height to which the mercury rises is a measure of the amount of atmospheric pressure removed or the vacuum in the condenser. By simultaneous readings of these two instruments is given the amount of absolute back pressure remaining in inches of mercury, and the latter multiplied by 0.491 reduces it to the back pressure in pounds per square inch.

Making Corrections for Barometer Readings

Absolute pressures in steam tables are based on a barometer reading of 29.92 or 30 in., depending upon the standard of temperature taken of the column of mercury, the temperature of the foregoing barometer readings being 32 deg. F. and 58 deg. F., respectively. Inasmuch as the atmospheric pressure is variable, as is indicated by the rise and fall of the barometer, it is necessary in order to make readings of the higher vacuum be of value for purpose of comparison of performance, or when dealing with steam values, to change the observed vacuum reading to one based upon a common barometer reading of 30 in.

It is obvious that the same condition of back pressure does not exist, if on two successive days the observed vacuum reads 28.5 in. and on one day the barometer reads 29.6 in. and the other day 30.3 in. Yet, if the barometer were not taken into consideration, it would naturally be thought that on both of these days, with the same vacuum indication, the condenser performance was the same, and the same degree of back pressure remained to be exhausted against.

It is plain that on the first day with a barometer of 29.6 in. the absolute pressure remaining is less than when the barometer reads 30.3 in. For instance, $(29.6 - 28.5) \times 0.491 = 0.54$ lb. absolute and $(30.3 - 28.5) \times 0.491 = 0.88$ lb. absolute. The customary method in recording vacuum is to use the indicated vacuum and not the absolute pressure and for the purpose of utilizing steam table values the observed vacuum must be corrected to a standard barometer of 30 in.

When the barometer reads above 30 in. subtract the difference between the actual barometer and 30 from the indicated vacuum; for instance, $30.3 - 30 = 0.3$ and $28.5 - 0.3 = 28.2$ the corrected vacuum referred to a 30-in. barometer. When the barometer reads below 30 in. add the difference between 30 in. and the actual barometer to the observed vacuum, as $30 - 29.6 = 0.4$ and $28.5 + 0.4 = 29.9$ in., the corrected vacuum referred to 30-in. barometer.

On both of these readings of 28.5 in. indicated vacuum when corrected for the difference in absolute pressures and changed to a common standard barometer of 30 in. show that the actual conditions of back pressure are quite different. At the lower vacuums carried on reciprocating units, it is not necessary to make such corrections, as they are really only of value in turbine plants operating under the best possible conditions of back pressure and where the effort is made to reduce this to the utmost.

(To be continued.)

Turbines and Condensers*

Operation of Large Units and Difficulties Encountered; the Steam Air Ejector

THE accompanying tabulation shows the total generating capacity of a number of large central station companies as of May 1, 1919. It also shows the generating capacity in machines of 20,000 kv.a. and larger, as well as the relation which this capacity bears to the total generating capacity. In the third column is the capacity of the largest unit and its percentage of the total capacity. With cross compound machines having two and three prime movers and generators, the complete machine is considered as a unit.

While this list may be subject to revision in minor details, it gives an idea of the tendency of the times so far as the installation of large generating units is concerned.

CENTRAL STATION SYSTEM CAPACITIES AND LARGE UNIT INSTALLATION AS OF MAY 1, 1919

Company and Location	Generating Capacity Total Kv-a.	Capacity in 20,000 Kv-a. and Larger		Capacity of Largest Unit	
		Kv-a.	% of Total Kv-a.	Kv-a.	% of Total Kv-a.
Buffalo Gen. Elec. Co. Buffalo, N. Y.	105,555	105,555	100.	38,889	36.8
Con. Gas El. Lt. & Pr. Co. Baltimore, Md.	81,500	40,000	49.1	20,000	24.6
Boston Elev. Ry. Co. Boston, Mass.	122,500	35,000	28.5	35,000	28.5
Edison El. Illg. Co. Boston, Mass.	143,000	30,000	23.8	30,000	23.6
Alabama Power Co. Birmingham, Ala.	140,233	58,333	41.6	33,333	23.8
Edison Elec. Illg. Co. Brooklyn, N. Y.	121,500	52,000	42.7	30,000	24.7
Bklyn. Rap. Tr. Co. Brooklyn, N. Y.	139,650	51,100	36.6	30,000	21.5
Commonwealth Ed. Co. Chicago, Ill.	498,510	227,910	45.7	35,300	7.1
Cleveland El. Illg. Co. Cleveland, O.	208,000	150,000	72.1	31,250	15.0
Union Gas & Elec. Co. Cincinnati, O.	84,400	50,000	59.3	25,000	29.6
Northern Ohio Trac. Co. Cuyahoga Falls, O.	67,000	44,444	66.3	22,222	33.2
Detroit Edison Co. Detroit, Mich.	193,000	105,000	54.4	45,000	23.3
Pennsylvania R. R. Co. Long Isl. City, N. Y.	78,000	41,100	52.7	21,100	27.1
Twin City Rap. Tr. Co. Minneapolis, Minn.	65,000	20,000	30.8	20,000	30.8
Interborough Rap. Tr. Co. New York City	389,000	256,000	65.8	70,000	18.0
New York Edison Co. New York City	286,000	111,000	38.8	30,000	10.5
Public Serv. Elec. Co. Newark, N. J.	255,100	105,000	45.0	35,000	15.0
United El. Lt. & Pwr. Co. New York City	124,900	65,900	52.8	25,900	20.7
Philadelphia Elec. Co. Philadelphia, Pa.	279,700	153,900	55.1	35,000	12.5
Narragansett El. Ltg. Co. Providence, R. I.	85,500	67,500	78.9	47,500	55.5
Duquesne Light Co. Pittsburgh, Pa.	168,000	47,200	28.2	47,200	28.2
Reading Tran. & Lt. Co. Reading, Pa.	25,000	25,000	100.0	25,000	100.0
Un. El. Lt. & Pwr. Co. St. Louis, Mo.	83,000	25,000	30.1	25,000	30.1
United Electric Co. Springfield, Mass.	45,020	20,000	44.4	20,000	44.4
Toledo Ry. & Lt. Co. Toledo, O.	88,000	45,750	47.0	25,500	25.7
Wheeling Electric Co. Windsor, W. Va.	69,000	60,000	87.0	30,000	43.5

In capacities up to 30,000 kw.; and although one single unit of 45,000 kw. capacity is now in service, it cannot be assumed that the size of single shaft units can be increased indefinitely.

From a manufacturing standpoint, the limitation in size of a single shaft unit is a limitation arising partly from materials at present available for blades and revolving elements and also from several inherent constructional difficulties which must be cleared away before further increases are fully justified.

In addition, there is also involved the question of economic value of increased size of machines above 30,000 kw. If such factors as maximum efficiencies, cost per kw., and space requirements show a fairly uniform betterment as the size of the unit is increased, then neglecting the factors of design and operation, an increase in the capacity of the single unit will show a saving with increased system load demand.

It can readily be appreciated that the system which has a large fraction of its generating capacity tied up in one unit is staking its reputation on the successful performance of that unit, and for that reason the manufacturer must naturally feel a heavy responsibility.

During the past two years there has been a marked increase in the number of large turbo-generator units in operation, particularly the horizontal, single shaft type of approximately 30,000 kw. capacity. This condition has been brought about by the necessity for meeting the rapidly increasing density of load, particularly in our larger centers of power supply, and the recognized reliability of operation recorded for this size of unit.

A consideration of the practical limit in size of single shaft machines, so far as the questions of design enter into the problem, indicates that in general higher efficiencies at equal or less cost per kilowatt output can be obtained as the size of the unit is increased, particularly

It would appear, however, that with the present constructional problems of prevailing frequencies and speeds and the recognized factors of safety, efficiency and cost, the size of systems today will hardly warrant units larger than 30,000 kw. capacity. In particular cases, and until increased reliability, as well as improvements in operating efficiencies, have been established, even larger systems will not justify the use of larger units.

Balanced against these machine characteristics must also be considered the system characteristics—size of load, load factor, available running time and minimum reserve capacity. As the proportion of single unit size to the system load is increased, there is obviously an added necessity for increased reliability, as well as for a higher grade of operating supervision.

The problem that must be considered, therefore, in

* Abstract of Report of Committee on Prime Movers read before the N. E. L. A.

increasing the size of horizontal, single shaft units, is one relating both to the question of system capacity and that of economic considerations of design and construction. During the entire period of the development of steam turbine generator units, operating companies, in order to increase their operating efficiencies, have in many cases purchased new designs before their reliability had been demonstrated. With the increasing proportion and importance of the individual unit as compared with the system capacity, it is of increasing importance in considering the future problems of operating these large units that progress be such as to insure more definitely that the demands of the central station companies for greater reliability of service can be met with an adequate degree of certainty.

Continuity of Service

The increasing size of prime movers and the increasing percentage which the individual turbo-generator unit bears to the total generating capacity of any system make the reliability of this type of machine a matter of much more importance from the operating standpoint than it was previously considered. While everybody appreciates the reduction in overhead charges due to the low investment cost per unit installed for these large machines, the low operating cost due to their increased efficiency and the low attendant labor and maintenance costs, yet operating companies must not forget for an instant that continuity of service is the bed rock of any central station company's reputation and that the truly successful public service company must give the community it serves the best and most reliable service possible.

With the increase in the size of the system and the recent increase in size of single units, an individual prime mover and generator often comprises 25 per cent or more of the total generating capacity of many large companies, and the importance of these large units, as well as the necessity for their continuous operation, have increased proportionately. It is therefore becoming increasingly onerous on account of overhead charges to attempt to safeguard this capacity, and the reliable operation of the unit is absolutely essential to the satisfactory operation of the system.

While it is most commendable to purchase that machine which will give, not only the lowest investment cost per kilowatt, but also the lowest operating cost per kilowatt-hour, there is a definite relation between the capacity of the individual unit and the capacity of the system beyond which it is neither safe nor wise to go. When the failure of a unit jeopardizes the service, the company's reputation is at stake, and the loss in prestige built up by years of faithful service may be more costly than the comparatively small saving in operating costs.

Just how far it is safe to go in the installation of large generating units each company must, of course, decide for itself, but since units of over 20,000-kw. capacity are a rather recent development, and since the service factor or ratio of hours available to total hours for some of these units is 90 per cent or less, as compared with 97 to 99 per cent for some of the older units, the importance of giving this matter careful consideration is evident.

On the other hand, it must not be forgotten that certain of these large machines have records of continuous performance and output which surpass anything previously considered possible. For example, one of the 25,000-kw. units operated at 67 per cent load factor during a 51-day run without shutdown; another machine of the same capacity has completed two 77-day runs, at 67 per cent load factor in the first instance and 70 per cent in the second, while one of the 35,000-kw. units operated at 65 per cent load factor for a 70-day run without shutdown.

Records such as these encourage central station companies to depend upon a single unit for over 25 per cent of their generating capacity.

Troubles with Large Units

During the past few years a marked development has been experienced in both the increased number and size of steam-turbo generating units in plants of the larger operating companies. This exceptionally rapid advance is largely due to two factors; first, the necessities of large operating companies to meet satisfactorily the service demands placed upon them, and, second, the important changes in design and construction, resulting

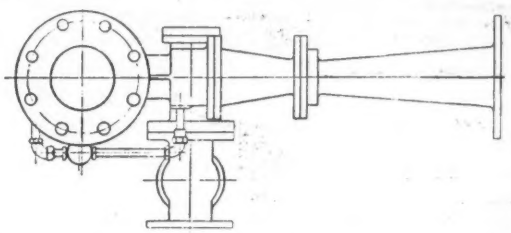


FIG. 1. A TYPICAL AIR EJECTOR FOR USE IN CONJUNCTION WITH CONDENSERS

in lowered cost and improved operation, that have made practicable the manufacture and operation of larger sized single units.

The experience of the operators with these latest type horizontal single units of 20,000-kw. capacity and above, covers a period of practically 3 yr. Therefore, any statement concerning these units at this time, which deals with their relative successes as compared with the smaller and earlier types, can hardly be regarded as altogether conclusive. Another element also to be recognized is that during this comparatively short period of time not only the manufacture but also the operation have been carried on under most adverse conditions as affecting both labor and materials. Nevertheless, a number of serious accidents, which have occurred only recently throughout the country, cannot be lightly regarded, particularly at this period of increasing high standards of service and operating economies.

In analyzing the causes of trouble as indicated by the operating records of the class of units of 20,000 kw. and over, there are several features of design that appear to be the most frequent sources of trouble. Labyrinth packings and thrust bearings have probably contributed to the major part of large turbine operating difficulties. While these troubles in themselves have caused a considerable loss in operating time, they have also been responsible in a considerable number of instances for the development of far more serious troubles. Among these may be mentioned excessive vibration of parts, break-

ing of buckets and dangerous rubbing of stationary and moving elements, which, in extreme cases, have resulted in permanent deflection of shafts.

The most serious situation that has developed in the type and sizes of units under consideration, however, has been the number of quite recent turbine wheel failures. In several instances these accidents have resulted in the complete wrecking of the units concerned. Such accidents, which are without parallel in the history of steam turbine development, can hardly be considered as bearing directly on the question of performance of large sized units, but rather as a factor to be considered in the improvement of design and construction of a specific type of unit.

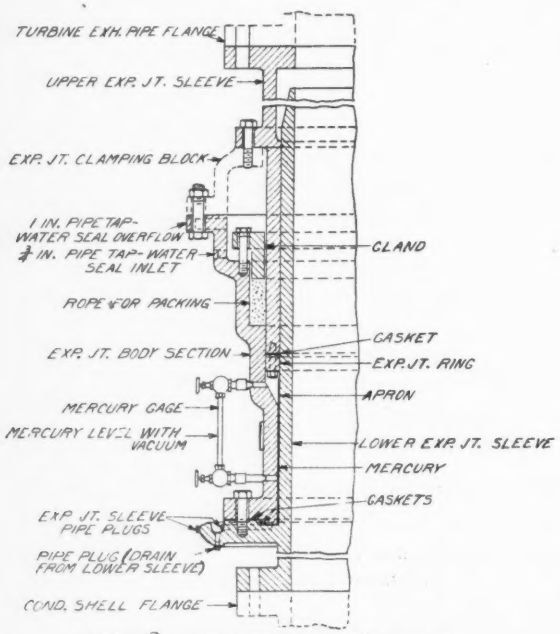


FIG. 2. THE MERCURY SEAL JOINT

The situation is now a critical one, and, while any definite statement at this time would be premature, the Committee wishes to indicate the necessity for early action both in safeguarding against further possible failures of machines now in operation, and in definitely reaching solutions of those problems which involve important features of design and construction.

In general, however, the records of operating performances of these larger sized units, while too incomplete for definite conclusions, do indicate that there is every reason to expect as high a standard of performance for the recent types of large capacity single shaft units as had been obtained in the operation of machines of earlier design and smaller capacities. It is hardly over-stating the case, however, to say that the records for reliability of operation of the larger units, during the past two years, have not been up to this standard.

While some of the difficulties may, without doubt, be directly concerned with operation, the greater percentage of trouble has been the direct result of shortcomings in details of design, materials or construction. On smaller sized units, however, similar details of construction have proved to be much more reliable in their operation. It would seem that not only is the same degree of reliability of operation essential, but that a greater degree of reliability becomes more imperative with increasing sizes of machines and higher standards of service demanded by those industries dependent upon electric power supply.

Standby Operation of Turbines

THE SUBJECT of "standby" or "floating" operation of a turbine, i.e., running it at or near zero load, is of special interest where steam plants are connected to transmission systems normally fed by hydro-electric power. There are two main cases: the first, or standby service proper, in which the turbine is kept running with steam at the throttle, so as to pick up load promptly in case of hydro-electric plant or line failure; and the second, or voltage regulating service, in which the turbine unit is motored from the generator end, using the latter as a synchronous condenser and employing only such steam as is necessary to prevent heating in the steam end. The first of these cases is the more important, as the standard turbogenerator is not especially fitted for synchronous condenser service, on account of field limitations, and because the losses are much greater than in a condenser designed for the purpose. Actual experience has been had with one or both classes of floating service on various hydro-electric power transmission systems.

According to information received, it is necessary with practically all types of turbines of any considerable size to maintain some steam passing through the turbine, to prevent injurious heating of the rotor and stator parts due to churning of the air. With boilers hot and ready to furnish considerable quantities of steam at short notice, the supplying of a few thousand pounds an hour does not call for heavy additional expenditure. It is even found advantageous in some cases to pass enough steam through the turbine to carry a few hundred kilowatts load, as this tends to give stability to the operation. The governor is adjusted so that load will be picked up by the turbine as the frequency of the system drops, from trouble or other cause. Difficulties are sometimes encountered due to a sensitive turbine governor, the steam machine tending to take up system fluctuations rather than leaving this duty to the hydro-electric plants.

The chief problem in normal standby operation is to determine how steam use can be kept at a minimum, still maintaining the turbine ready to pick up load without delay. In any case the turbine valves should be adjusted to take the smallest amount of steam consistent with safety to the internal parts and with proper regulation.

For standby operation it is desirable that the exciter be direct driven by the turbine. It is necessary to maintain a vacuum on the turbine, and to keep the condenser auxiliaries in operation, and these would preferably be motor driven if the steam turbine is of sufficient size to maintain frequency and voltage with trouble on the transmission line or in the hydro-electric plants running in parallel; if the turbine cannot be expected under these conditions to hold up speed and voltage, the important auxiliaries should be steam driven or should have a combination electric and steam drive, with the electric used normally but with the steam drive arranged to pick them up at the time of serious trouble on the system.

One of the most important features in keeping down expense in standby operation is the manner of handling the boilers. With coal fuel, either an underfeed stoker, or a forced draft chain grate stoker, or perhaps powdered fuel, may be chosen for this banking and quick steaming work; in many instances oil or other liquid or gas fuel can be used to advantage. It is difficult, however, to use oil successfully, in a normally coal-fired furnace, to give quick steaming in emergency. The speed of the stoker or the supply of fuel oil can, if desired, be made automatically responsive to an increase in load. There are various schemes of keeping the boilers up to a reasonable pressure, such, for instance, as keeping one boiler fired actively and using live steam therefrom in all others. It is desirable to have a large storage of hot water in the heaters and in auxiliary tanks to assist in maintaining maximum evaporation during the first few minutes of active turbine operation.

It appears that the operation of steam turbines at no load in parallel with hydro-electric systems is tending to become less frequent, not only on account of the necessity for rigid economy, but because hydro-electric plants and transmission lines are more reliable.

Condensers

During the last two years there has been developed the steam air ejector, which has come into a very prominent place in marine work, and is rapidly coming to the front in its application to power plants. Its unqualified success at sea has shown that it is an apparatus that will soon occupy a prominent place in future condenser installations. We, therefore, believe it should be brought to the attention of those concerned with condenser equipment for power houses.

Ejectors as made by the various manufacturers are usually built in two stages, each stage partially compressing the air by ejector action. In one design of this apparatus, the second stage handles both steam and air from the first stage. In another, there is a condenser between the two stages which condenses the steam delivered from the first stage so that the second stage has to compress air only. Better efficiencies and steam consumptions are obtained with this latter type; but as the steam consumption of ejector apparatus is generally low in comparison with the total auxiliary steam, manufacturers of the type not using the intermediate condenser claim that the extra complication is unwarranted. This is probably a fact where the station has a proper heat balance, inasmuch as the ejector without the intermediary condenser returns practically all its heat to the heater. This latter characteristic is a thing worth mentioning. As pointed out by the ejector manufacturers, while the steam consumption of an ejector may be slightly higher than that of an hydraulic air pump of the same capacity, its overall efficiency is greater. The hydraulic air pump takes its water from the intake tunnel and discharges back into it, losing the heat equivalent of the mechanical work done. It also loses some heat due to the discharge of steam and heated air from the condenser. The steam ejector can discharge into a surge tank, and thus recover practically all the heat that it uses.

Some caution must be used in the installation of these ejectors. The difficulty is that the exhaust from the ejector contains all the air that has been pumped out of the condenser. It is not safe to discharge the steam and air from these ejectors into the present type of heaters. There should be installed a large surge tank into which the make-up and the discharge from the air ejectors should be carried. The tank should have a free atmospheric vent for the discharge of the air, allowing the water from the tank to overflow into the heaters.

A large manufacturer recommends hanging the condenser from the turbine foundation, a method which accomplishes practically the same results as the spring. In one case, where the condenser was located 50 ft. below the turbine and there was an unusual amount of expansion in the exhaust piping, the expansion joint was of the mercury type. This joint, which is illustrated in Fig. 2, is nothing more than a mercury seal in the exhaust line, and it allows absolute freedom of expansion. It seals against any vacuum and is even capable of sealing against 5 lb. back pressure.

Test Results Versus Operating Results

By T. A. Marsh

After all, it is the daily, weekly, monthly and yearly results that count. Tests are good and have their place. No rational study of combustion and plant efficiency can be carried on without some tests for guidance.

Tests, however, to establish operating conditions should be made under as nearly those operating conditions as is possible. The making of a boiler test usually entails the presence of two to four experts on boilers, stokers and combustion. Someone has suggested that results should be reduced 5 per cent for the presence of each stoker man on the job. Results are frequently obtained by operating under carefully supervised attention that cannot be duplicated in practice, either from an operating or maintenance standpoint.

With many types of stokers, the skill and judgment of the fireman as to when to dump clinker and clean fires with those stokers that are not automatic in ash and clinker removal, is such a potent item that efficient operation with such stokers ranges from 5 to 10 per cent lower than test results.

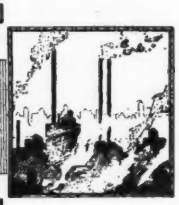
Test results with such types of stokers serve, therefore, to indicate only the skill and perhaps cupidity of some expert and have no bearing on operating results. This is particularly striking in the light of the fact that the plants which seem to be capable of making the highest efficiencies on test runs are not the plants which are producing kilowatt hours on the least pounds of coal or heat units.

The real operating principle involved is simplicity of equipment and ease with which the average operative can duplicate the results of the expert.

From test figures, it is possible to figure a theoretical rate of approximately 15,500 B.t.u. per kilowatt hour, but in daily operation few, if any, plants get as low as 20,000.

The quicker, therefore, we realize that we are not designing plants or building them to make tests, but to make steam and to make it under practical operating conditions, the sooner we shall approach the best theoretical figures of operation for the equipment installed.

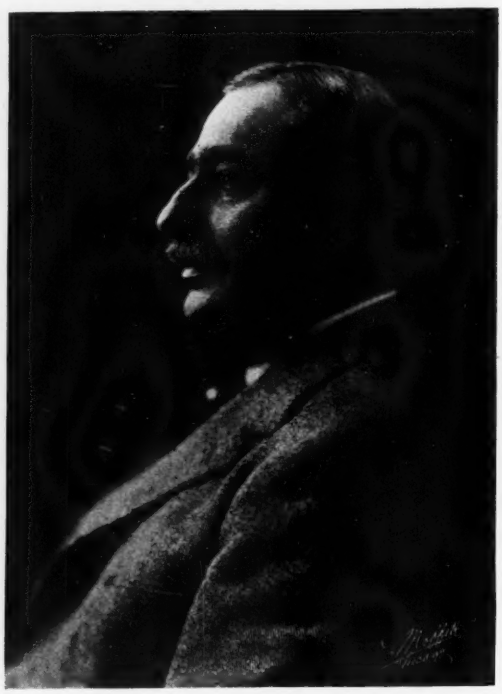
H. M. BYLLESBY



STARTED IN DYNAMO SHOP. PERFECTED FIRST PRACTICAL A.C. LIGHTING APPARATUS. ORGANIZED SUCCESSFUL HYDRO-ELECTRIC PROJECTS. FINANCIER AND DIRECTOR, ENGINEER AND PATRIOT. BY PAUL CRISSEY.

WE ARE looking for a man with a *punch,"* said a Washington army official a month or two after America went into the war.

And so they invited Henry M. Byllesby to don a uniform and put on the three-track stripes of a major and come to Washington. When he was mustered out of the service a short time ago, he wore the silver leaf of a lieutenant-colonel and had earned the respect of the British army officials in England for his work in assisting Brig. Gen. Charles G. Dawes in the purchasing department of the oversea forces abroad.



The man with the punch! That is Henry Marison Byllesby, engineer, organizer, financier, constructor and operator, and head of H. M. Byllesby & Co., one of the largest public utility organizations in the United States.

There was a day, back in the time when Samuel Insull knew more about the mysteries of shorthand than he did about public service corporations, and when he and Thomas A. Edison were trying to get their shoulders above water, when Byllesby, then a draftsman in Edison's employ, little dreamed (or maybe he did) that some day he would be at the head of an organization responsible for growing utilities companies which would serve 2,000,000 people in more than 16 states scattered throughout the country. Yet, in 1918, that is exactly where Mr. Byllesby stood.

Next to the fact that Mr. Byllesby was born in Pittsburgh, Pa., in 1859, the most important item of interest is that he was the son of a clergyman, but failed to fulfill the time-worn expectation for a minister's son. His education was obtained at Western University of Pennsylvania, after which, until 1877, he took a course in mechanical engineering at Lehigh University. Not waiting to graduate, he went to work in the laboratory of a dynamo and electric machine shop. Here the practical experience he had gained by working during his vacation for twelve years stood him in good stead, and before long he went into the drafting room of the Corliss Engine and Mill Machinery Plant at Chester, Pa.

Then came his first connection with the electrical industry when, on June 1, 1881, he went to work for the Edison Co. for Isolated Lighting in New York City. A few months in the drawing room there brought a promotion, and he went to the Pearl Street Station of the original Edison Electric Illuminating Co., of New York.

Under the direction of the chief engineer and his assistant, Mr. Byllesby made all of the drawings for the structures, cranes, location of boilers, engines and switchboards of this plant, which was the first steam operated central power plant in the United States.

This work demonstrated his ability, and with an eye to the future, Mr. Byllesby accepted an opportunity to go to Canada to supervise the manufacture of Central electric devices, dynamos, etc. From 1884 to 1885 he was on the engineering staff of the Edison Co., but resigned to become Eastern Manager for Robert Wetherill & Co.

. About this time Mr. Byllesby became interested in the work of George Westinghouse, of the Union Switch & Signal Co., who was venturing out on his own capital in some electric lighting project. At Mr. Westinghouse's request, he became associated in these ventures, and soon afterward the Westinghouse Electric Co. was formed, with Mr. Byllesby as its vice-president and general manager.

Mr. Westinghouse had purchased previously of Goulard & Gibbs the patents on alternating-current machinery, and Mr. Byllesby plunged into the work of perfecting these devices and planning for their extensive manufacture and operations. He was keenly appreciative of the promises which these new machines and alternating current held forth, and in 1886 he turned

out, with the aid of his associates, the first commercially practical alternating-current electric lighting apparatus.

The success of the machine was immediate, and the company expanded so rapidly that eventually it bought the works of the Union Switch & Signal Co. The demand for current became heavy and with it arose the need for numerous devices. Into the inventing and perfecting of these new devices, as well as managing the selling end and keeping in touch with the commercial situation, Mr. Byllesby poured his time and his knowledge, with the result that more than 40 patents on various electric lighting devices were taken out in his name, or as an associate inventor, within a short period.

European fields loomed big on the horizon, and for two years, from 1889 to 1891, Mr. Byllesby spent most of his time abroad, representing the Westinghouse Co. Then suddenly, because of a difference of opinion with Mr. Westinghouse on financial affairs of the company, he resigned to become connected with the Thomson-Houston Co., which connection he maintained until it was absorbed by the General Electric Co.

Then there came to him the vision of generating current on a big scale by harnessing the swift running rivers of the Northwest. One of the first large pieces of construction work which he undertook successfully along this line was the building and financing of the original water power plant on the Willamette River at Oregon City. From 1894 to 1898, he explored Montana's waterways and constructed two hydro-electric projects and formulated plans which led eventually to the development of the Montana Power Co.

Many of the undertakings which interested Mr. Byllesby in those days of "cruising" and exploring were financed by himself, notably the Big Hole River Plant near Butte, where he personally had charge of and financed the construction of a plant with an installed capacity of 4000 hp. and reservoirs 30 mi. upstream. Northern Minnesota also held out alluring inducements for the development of hydro-electric plants.

Opportunity, it would seem to one who has watched Mr. Byllesby's career, was the one and only thing which he desired; and he has a wonderful faculty for lifting the veil and seeking opportunity, then throwing all his energy, resources and experience into improving that opportunity.

On Jan. 1, 1902, he organized the engineering firm of H. M. Byllesby & Co., of which he is president. At the outset, the activities of the concern were almost entirely engineering; but under Mr. Byllesby's able hand, the company expanded rapidly and shortly won distinction as one of the largest financing, designing, constructing and managing organizations in the electric light and power, gas and street railway fields.

In this work Mr. Byllesby displayed his skill as an organizer, working always toward greater efficiency in the operation of the scores of companies under his control. Consolidations were effected, properties were linked and grouped together for more efficient operation and in order to give the maximum of service.

"The price of happiness is toil." Mr. Byllesby believes it whole-heartedly, and he believes also in living up to ideals, whether they apply to business or simply to an individual's own existence. On this subject he once said: "The ideals which we have established and which we are endeavoring conscientiously to carry out are ideals which heretofore have not been very successful, and a great many people today think that sooner or later we will have to abandon them. Keep the organization up to its present standard!"

That, in brief, was his message to those who work under him—his key to success—living up to ideals.

But one of the greatest factors which has contributed to the success of Mr. Byllesby is his ability to judge men and to surround himself with the sort of men with whom he can work in harmony. He has ever a ready ear for advice—seldom gives but is eager to receive it. His company was one of the first of its kind to institute the "council table," wherein engineering and financial matters were discussed and decisions reached by the various combined efforts of a number of men who are experts and specialists in certain specific lines.

"Two heads are better than one." And so it has been with Mr. Byllesby, who has, in his years of experience, come to appreciate that the other man's ideas may be as valuable as his own.

Preventing Disintegration of Cement Floors

By Mark Meredith

FOR various reasons cement floors will become dusty and begin to disintegrate, and where this happens it is rather a nuisance, especially when currents of air cause the dust to rise. Where the floor is not greasy, it is a good plan to wet it all over thoroughly each evening, using a 5 per cent solution of soluble water glass—soluble silicate of soda—applied with a watering can as made for garden use. The action of the silicate is to cause silification of the components of the floor and thus hold them together, dustiness soon being stopped by this means. Floors made with fresh Portland cement and clean shingle or granite chippings as an aggregate, and enough clean sharp sand as a filler, if properly mixed and laid should not disintegrate under ordinary traffic, but a little dirt in the material will cause a lot of trouble. For a 4-in. floor such as would be laid on a rammed rubble foundation, four parts of hard tone held by a ⅛-in. mesh and passing a ¾-in. mesh sieve, two parts of sharp sand free from clay or other dirt and one part fresh Portland cement, twice mixed dry and then wetted and placed in the position it is to occupy, would, after a reasonable time for hardening, stand any ordinary factory wear, always provided the men laying the floor understand their work. Old cement, or that which has set hard in the bags, is of no use for floor work.

In a paper recently read by D. M. Buck before the American Society for Testing Materials, it was brought out that very small amounts of copper have the effect of reducing corrosion in steel. Tests were made of open hearth steel with various copper additions, so that there was from 0.012 to 0.254 per cent of copper in the ingots. These were rolled into sheets and exposed to the atmosphere in the Connellsville coke region, together with a number of pieces in which there was no copper. It was found that a mere trace of copper was sufficient to prevent rapid corrosion.—Scientific American.

Keeping Up the Temperature of Feed Water

PROVISIONS TO MAKE AND CONDITIONS TO WATCH TO MAINTAIN HIGHEST EFFICIENCY. BY M. A. SALLER

RANKING among the most important of the factors affecting boiler plant efficiency and power economy as a whole is the matter of the boiler feed water temperature, and the maintenance of this at the highest possible point. It has been established by theory, and conclusively proven in practice, that each 11 deg. rise in temperature of the boiler feed water results in a reduction in fuel required to the extent of about one per cent. In other words, the boiler feed water temperature has a very direct and marked bearing on the economy and service.

Besides this direct effect on the economy of the boiler, it should also be borne in mind that the feeding of boiling hot water into the boiler, ready to be quickly flashed into steam, greatly enhances the steaming capacity of the unit and makes it more capable of responding to sudden loads and overloads. The elimination of expansion and contraction strains which are bound to occur where comparatively cold water is injected into the hot mass of the water in the boiler is also another important factor.

This increase in the feed water temperature can be secured in several ways; by utilizing the exhaust steam from engines, pumps, etc., utilizing some of the heat from the exhaust steam going to surface condensers or between primary and secondary cylinders of compound engines; or by utilizing the heat in the waste gases from the furnace, as in the case of the economizer.

By far the most commonly used method is the utilization of exhaust steam in feed water heaters, which can be of the open or closed type, depending on conditions, and since the majority of plants are equipped with apparatus of this kind in connection with their endeavor to keep up the boiler feed temperature, some of the features of operation will be taken up.

The first step in the attempt to utilize exhaust steam for heating the feed is to rid the steam of the lubricating oil contained in it, and for this the commercial oil separator gives entirely satisfactory results. It is absolutely essential to remove the oil from the steam used in open heaters because the steam comes into direct contact with the water and mixes with it; in the closed type it is desirable to get rid of the oil because the heating surfaces will be kept clean and up to their highest efficiency, and then again the steam condensed in the heater can be conserved and put into the hot well as pure, hot water.

It is also highly important that the feed-water heaters be kept clean, not only from oil, but from mud, scale and other sediment. In sections where the water contains quantities of scale forming matter, the surfaces of a tubular heater will usually coat up very quickly, with apparent impairment of efficiency. In those cases, the open type apparatus is more suitable because the accumulation of scale and mud has less effect on the feed temperature, and because this type can be more readily cleaned out, either by removing the trays or pulling out the sludge and sediment through the clean-out doors ordinarily provided.

Every feed heater ought to be provided with a good reliable thermometer so that the engineer can tell just what the feed temperature is, when it is falling below the desirable point, and when it is necessary to clean or overhaul the heater. In some plants, the heaters need be cleaned only once or twice in the course of a year. In other plants, enough scale and sediment collect to make advisable cleaning out every week or two; and it is advisable to clean this equipment when necessary not only because of the falling off in temperature which will follow, but also because all the mud and scale that is not retained in and removed from the heater will eventually find its way into the boilers.

In connection with open heaters, one of the most common causes for low feed temperature is the matter of air logging or air binding. The breaking up of the cold water and the heating up of it by the exhaust steam drives off a very appreciable quantity of air and gases; and as no outlet is provided for these gases, they will accumulate in the heater and form an air pocket which eventually will crowd out the steam and will not allow it to mix properly with the water. Case after case can be cited where the feed water was being heated to only 180 or 190 deg., when the mere opening of the gate valve in the vent line to atmosphere caused the temperature to jump in the course of a few minutes to 205 or 210 deg. So it is highly important that the heater is provided with a vent amply large to carry off the air and gases driven off the water. It is usually advisable to make the vent pipe of 1 or 2 in. size, or larger, and then provide it with a gate valve by means of which it can be throttled down just to permit the escape of air and gases without too great a waste of steam. Care should be taken, however, that the valve is not completely closed.

The heaters can usually be installed on a dead-end or induction method whereby the heater draws exhaust steam in just sufficient quantity to heat the water, the balance of the steam going to the heating system, or to atmosphere. Where the supply of steam is limited, however, it is then advisable to pass all the steam directly through the heater so that the heater will have the advantage of all the steam available.

In the heater it is also usually advisable to carry a plus pressure of ¼ or ½ lb. in order to insure the proper driving off of air and gases.

In connection with the endeavor to keep up the feed temperature, attention should also be paid to the importance of conserving hot return water and condensate wherever possible. Condensate from surface condensers, or heating coils, or any other source represents an excellent source of water supply, because it is pure distilled water, and because it also is at a comparatively high temperature, ranging from 100 to 190 deg. All such water should be brought together to a central storage tank or hot well, or discharged directly into the heater so that it will go to make up part of the feed supply, only sufficient raw cold water being introduced to make up the difference required to feed the boiler. Where returns from heating systems, etc., are being wasted because of the presence of oil, an attempt should be made to install oil separators on the steam supply mains so that

the oil will be removed prior to the use of the steam in the system.

In many plants where condensers are used, and where most of the auxiliaries are run by electric motors, there is a scarcity of steam for heating the feed water; but in such plants it is usually customary to heat the water to the highest temperature possible with the exhaust steam, and then pass the water through economizers in the boiler flues which heats the water to a high temperature. Where it is not deemed desirable to install economizers, arrangements can be made to shift over some of the auxiliaries from motor to steam drive to provide sufficient steam for heating the feed water to the best possible temperature.

In other plants they deem it good practice to draw live steam from the boilers to supplement the exhaust steam used for heating the water where otherwise the temperature would be rather low, this can be considered to be good practice because no thermal loss is experienced, while at the same time the boilers are given the advantage of having water fed to them ready to be flashed into steam.

It is sometimes encountered that the feed water temperature is purposely held low because some difficulty is experienced in pumping the hot water. This is an entirely unjustifiable state of affairs because if properly handled no more difficulty should be experienced in pumping hot water than cold. The main point to bear in mind is that the hot water must be allowed to flow to the pumps under gravity head—it cannot be raised against a suction head because, as soon as the suction is applied, the vapor tension of the hot water allows it to burst forth into steam or vapor, causing binding and knocking in the pump. Often the mere raising of the heater or the lowering of the feed pump will cure the trouble. Then attention should be paid to the pump valve springs to make sure that they are not too stiff, causing too great a friction loss through the valves. A stand-pipe erected near the pump to provide a good head of water right at the pump is also often a great help. Care should be taken also to keep the hot water line to the pump amply large so that the loss in friction will be kept to the minimum.

Leaks in the regulating, overflow or control valves on heaters also often cause a drop in the temperature because a large quantity of water is being wasted to overflow. This point should be carefully watched.

There is hardly one plant in a hundred where a feed temperature of 210 or 212 deg. or even more, could not be obtained if all the various factors and features were investigated, run down, and remedied. And considering that an 11 deg. rise saves 1 per cent in coal, the time and effort required for doing this is well worth while. So it behooves every operating engineer to see that his feed line is equipped with a thermometer so that he can immediately detect when his temperature is falling below the normal, and so that he may know when it is up to him to get busy and run down the cause of the falling in the feed temperature.

High Efficiency Pumping Units

Test Results of Motor Driven Centrifugal Pumps Show High Efficiency and Low Cost Using Off-Peak Current

In a paper read before the Minnesota Section of the American Water Works Association, F. W. Capellen stated that in May, 1911, the City of Minneapolis entered into a 10-yr. contract with the Minneapolis General Electric Co., now the Northern States Power Co., by which that company agreed to furnish current at 2200 v. to operate two or more 20,000,000-gal. pumps against a dynamic head of 240 ft., based upon a pumping set of 72 per cent overall efficiency, at a price of $4 per million gallons pumped, the understanding being that no current would be used between 4:15 and 6:30 p. m. on week days during the months of November, December, January and February. In November, 1916, a similar 10-yr. contract was made with the same company for the operation of a 30,000,000-gal. pump against the same head, and with the same pump efficiency, to be charged for at the same rate, with the provision that at a different dynamic head or efficiency, the price per million gallons should be adjusted accordingly. It was also specified that the motor to be used should be capable of starting the pump when primed and with the check or gate valve in the discharge closed, and of bringing the pump to full speed without drawing more than 150 per cent of full load current from the source of supply.

In 1910 and 1911, two 20,000,000-gal. pumps were installed, and in 1918, a unit consisting of an 1800-hp., 3-phase, slip-ring induction motor directly connected to two 24-in. single-stage pumps mounted upon the same base plate and connected in series. The unit was specified to deliver 30,000,000 gal. per 24 hr. against a total dynamic head of 250 ft.

The official acceptance test was made on May 28 and 29, 1918. The discharge was measured by means of a Venturi meter, the capacity being calculated from manometer reading, while the discharge head was measured by two sets of calibrated gages and the suction lift by means of a mercury column. The power supplied was measured by three sets of watthour meters, calibrated by means of a portable set of standard instruments read during the official test under the conditions of current, voltage and power factor obtaining. The portable set included two single-phase wattmeters, one polyphase wattmeter, one voltmeter, four ammeters, and portable current and potential transformers. All instruments were checked and calibrated in the presence of witnesses. The test lasted 28 hr.

The results were as follows:

Total pumpage in 28 hr	37,719,500 gal.
Rate per 24 hr.	32,331,000 gal.
Discharge head, average	235.13 ft.
Suction lift, average	16.43 ft.
Total dynamic head, average	251.56 ft.
Kilowatt-hours used	36,307.2
Combined efficiency of motor and pump	82.1 per cent
Average line voltage	2,406
Power factor	90.0 per cent
Motor efficiency under test conditions	95.5 per cent
Slip of induction motor	1.1 per cent

Temperature rise.....33 5 deg. C.
Starting current, percentage of full load current .....113.0 per cent

The contract provided a bonus of $500 for each one per cent of efficiency exceeding 76 per cent when pumping 30,000,000 gal. per day against a total dynamic head of 250 ft. The maximum bonus was limited to $2400. A penalty of $500 was provided for each one per cent by which the efficiency might fall below 76 per cent and the pump was not to be accepted if the over-all efficiency fell below 72 per cent. As the accompanying charts show, 76 per cent efficiency was exceeded at all loads tested, and the average combined efficiency, including the regular starting and other conditions incidental to a varying load in regular service, should not be less than 82.1 per cent by more than 1 per cent. The overall efficiency of 82.1 per cent divided by the motor efficiency of 95.5 per cent gives a pump efficiency of 85.97 per cent. This is believed to establish a new record and is 6 per cent higher than results obtained in tests on other pumps under similar conditions. Service runs extending over a

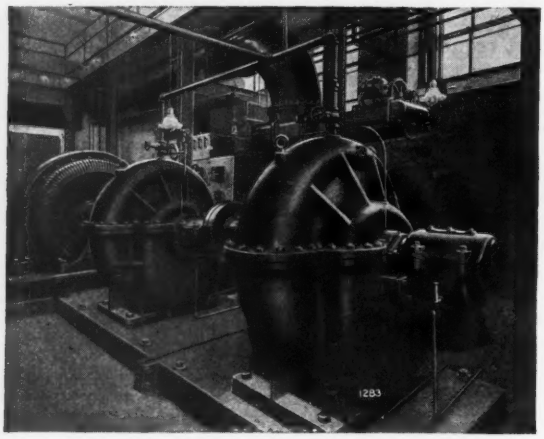


FIG. 1. MOTOR-DRIVEN CENTRIFUGAL PUMPING UNIT INSTALLED BY THE CITY OF MINNEAPOLIS

period of three months show an excess of 5 per cent over the efficiencies stipulated in the contract for various heads.

The following comparative operating data were obtained during the first three months after the test:

30,000,000-gal pump—	
Gallons pumped	2,797,490,000
Power cost per million gal.	$3.63
Labor and supplies per million gal.	2.27
Total cost per million gal.	5.95
Head, ft.	253.06
Overall efficiency, per cent.	81.4
20,000,000-gal. pump—	
Gallons pumped	421,340,000
Power cost per million gal. pumped	$4.15
Labor and supplies per million gal. pumped	2.27
Total cost per million gal.	6.42
Head, ft.	250.57
Overall efficiency, per cent.	72.3

Similar records for the first nine months subsequent to the test are as follows:

30,000,000-gal. pump—	
Gallons pumped	6,526,350,000
Power cost per million gal.	$3.72
Labor and supplies per million gal.	1.77
Total cost per million gal.	5.49
Head, ft.	255.80
Efficiency, per cent.	82.48
20,000,000-gal. pump—	
Gallons pumped	1,771,930,000
Power cost per million gal.	$4.33
Labor and supplies per million gal.	1.77
Total cost per million gal.	6.10
Head, ft.	257.80
Efficiency, per cent.	71.4

Figures are also available from two triple-expansion Holly A-frame pumps installed in the same plant in 1903 and 1904, and tested in September, 1904. These pumps have a capacity of 15,000,000 gal. per day each, and on test developed a duty of 162,000,000 ft.-lb. per 1000 lb. of steam, reduction being made for slip. During 1908 the two steam pumps raised practically all of the water for the city, namely, 6,518,000,000 gal., against 250 ft. head. The cost of fuel, using Illinois

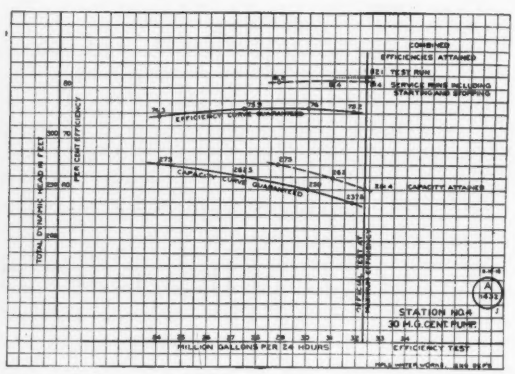


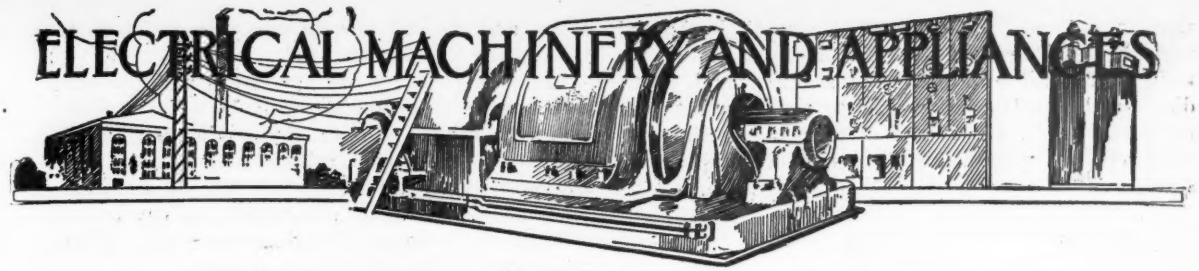
FIG. 2. HEAD, CAPACITY AND EFFICIENCY CURVE SHOWING RESULTS OF TESTS ON MOTOR-DRIVEN CENTRIFUGAL PUMPS AT MINNEAPOLIS

screenings at $2.07 per ton, was $3.01 per million gallons, the cost of labor $3.33, and other pumping costs 35 cents per million gallons, making a total of $6.75. The cost today, with coal at $4.93 per ton, would be approximately $12.74 per million gallons.

WRITING in Automotive Industries, W. F. Bradley states that 90 to 95 per cent of lubricating oil was reclaimed by an army emergency process known as the Meurisse method.

It seems that this system permits the regeneration of either castor oil or mineral oil, with a loss of 10 per cent or less, and at a cost of only 7½ cents a gallon. The oil is not only filtered but also is regenerated by using certain chemicals. No information is given out as to what these chemicals are, or how they are used, as the process is still considered a secret.

One firm alone, the Renault Co., was able to save during the war more than 50,000 gal. of oil by this method of reclamation. Many other French manufacturers also adopted the process, and then the army became interested and finally issued a general order that no lubricating oil should be thrown away.



Feeder Regulators---I

THEORY OF OPERATION AND DETAILS OF CONSTRUCTION OF THE SWITCH-TYPE MACHINE. BY V. E. JOHNSON

IN Fig. 1 is shown the connection of what is commonly called a "boosting" transformer. In this particular case the "boost" is 10 per cent, as determined by the ratio of transformation. This is a common application of a standard transformer and is an embodiment of the fundamental principle of feeder regulators.

The primary is connected across the mains while the secondary is in series with the load. The result is that the secondary voltage will be added (or subtracted from it if connection is made in the opposite direction), to the line voltage.

In Fig. 2 is a reproduction of Fig. 1, with the addition of figures to denote the value of voltage and current in the various parts of the circuit. It will be noted that the product of volts and amperes on the ingoing or line side equals the product of volts and amperes on the load side. A little consideration will show also that the size of the transformer need be only R per cent of the kilovolt ampere capacity of the feeder—where R is the regulation. In other words, the secondary of the transformer must be of sufficient ampere carrying capacity to permit the full line current to pass through it without heating.

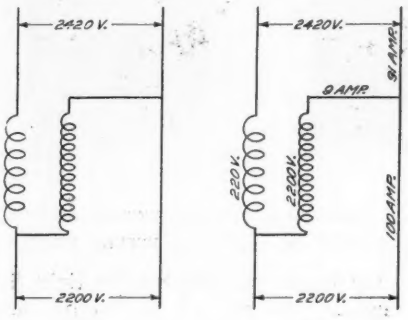


FIG. 1. DIAGRAM OF CONNECTIONS OF A BOOSTING TRANSFORMER

FIG. 2. BOOSTER TRANSFORMER CONNECTIONS SHOWING TYPICAL CURRENT AND VOLTAGE VALUES

In Fig. 3 is shown the next step in the evolution of a feeder regulator, namely: the introduction of a variable ratio boosting transformer. By using in conjunction with dial switch D, a reversing switch R, the same coils can be used both to raise and lower voltage. This, then, is in elementary form the arrangement of "step" type regulators as made today.

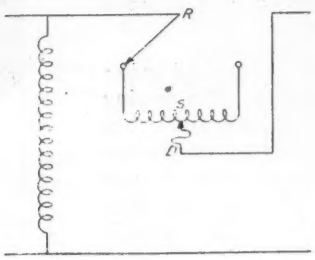


FIG. 3. DIAGRAM OF CONNECTIONS OF VARIABLE RATIO BOOSTING TRANSFORMER

In Fig. 4 is shown a feeder voltage regulator arranged for hand operation, while in Fig. 5 is the diagram of internal connections. Coils P1 and P2 are permanently connected across the line, while secondary S1 and S2 is in series with the line. The secondary is divided into sections, which are cut into circuit by the dial switch. By turning the handle from maximum boost (extreme counter clockwise position), step by step towards the right (clockwise), the boosting action is reduced until the dial switch rests on segment, where the secondary is entirely out of circuit and the line side voltage is the same as on the generator side Continuing rotation throws the reversing switch into the "bucking" position, and then gradually cuts in the secondary coils step by step until maximum "buck" is reached, when all the coils are again in the circuit. Thus two complete revolutions of the handle are necessary to complete the range of regulation from one extreme to the other.

FIG. 4. A TYPICAL FEEDER VOLTAGE REGULATOR ARRANGED FOR HAND OPERATION

One of the difficulties encountered in the design of any step by step regulator, is that of sparkless transi-

tion from one contact segment to the next. If the dial arm leaves one segment before it touches the next, the main circuit will be opened; on the other hand, if the dial arm be made wide enough to make contact with two segments at once, the coils or turns connected across these segments will, during the period of transition, be short-circuited.

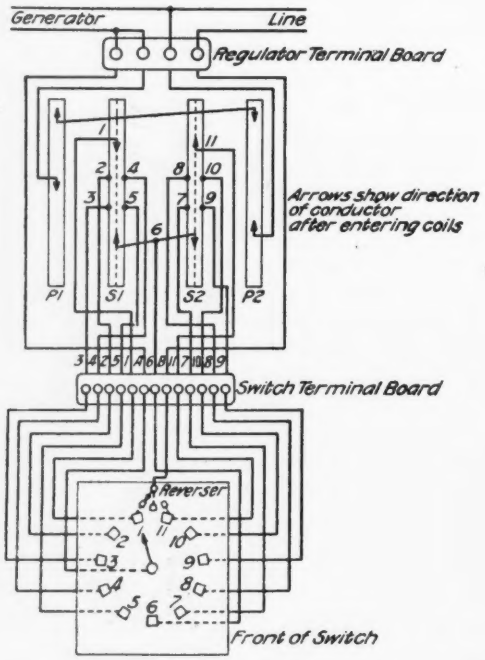


FIG. 5. DIAGRAM OF INTERNAL CONNECTIONS OF REGULATOR SHOWN IN FIG. 8

In the regulator shown in Fig. 4, the following method is used to overcome this difficulty. The moving arm is too narrow to bridge across two segments; but by means of a "quick break, quick make" mechanism somewhat similar to that employed in an ordinary snap switch, the period of open circuit in going from step to step is so short that no fluctuation of the lights is noticeable.

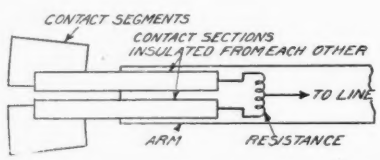


FIG. 6. REGULATOR CONTACTOR EQUIPPED WITH SHORT CIRCULATING RESISTANCE

Another type of arm is shown in elementary form in Fig. 6. During transition the current flows through resistance and so prevents opening of the main circuit without short-circuiting any coils.

On circuits with slow changes of load, a hand-operated regulator is satisfactory, particularly in small stations with only two or three feeders, and where constant attendance is possible. On circuits subjected to sudden non-periodic fluctuations, and in stations where the number of feeders makes manual operation difficult, resort must be had to automatic devices for operating the regulator mechanism.

In Figs. 7 and 8 we have illustrated the exterior and interior of a typical regulator, while in Fig. 9 is shown the scheme of connections. Figure 10 shows the dial switch, the outside cylindrical portion of which is stationary, while the inside shaft with its accompanying mechanism turns under the control of a contact making voltmeter and changes the voltage by a step adjustment analogous to that in the hand regulator.

The moving member consists of a casting bearing on its outer surface a number of contact fingers, each insulated from its neighbor and from the supporting member, but connected to a sliding brush on the inside. The top collector ring is connected through its brush and finger to a segment of the dial switch. The next to the top collector ring is similarly connected to the same segment and so on. The fingers are so placed that when

FIG. 7. EXTERIOR VIEW OF A TYPICAL FEEDER REGULATOR
FIG. 8. INTERIOR VIEW OF A TYPICAL FEEDER REGULATOR

the end of the top finger just touches the right hand edge of one segment, the end of the bottom finger just touches the corresponding edge of the next segment. By means of this arrangement, the opening of the secondary circuit at any stage is prevented; arcing is eliminated and finer regulation is obtained because the outgoing line is in a sense gradually moved from one segment to the next instead of being jumped one whole step as is the case in the hand operated regulator. The moving element being light has small inertia and responds instantaneously to changes of voltage.

The control mechanism of a switch type regulator is shown in Fig. 11. The regulator contact making mechanism is moved in the proper direction by means of a continuously running motor. Power is transmitted from this motor to a bevel gear which is keyed to the switch shaft. By a simple arrangement of clutches motion in either direction is produced.

The clutches are mechanically connected to the gears and electrically controlled by a contact making voltmeter. A lever, 3, is pivoted in the middle, and controlled by a plunger operating in a solenoid, 6. This solenoid is connected across the secondaries of a potential

transformer as shown. The movement of this plunger up or down makes contact between the lever and one of the stationary contacts 1 or 2 completing the circuit from common terminal 3 through 1 or 2 and thence through the "lowering" or "raising" clutch. By tracing out the diagram the operation is readily understood.

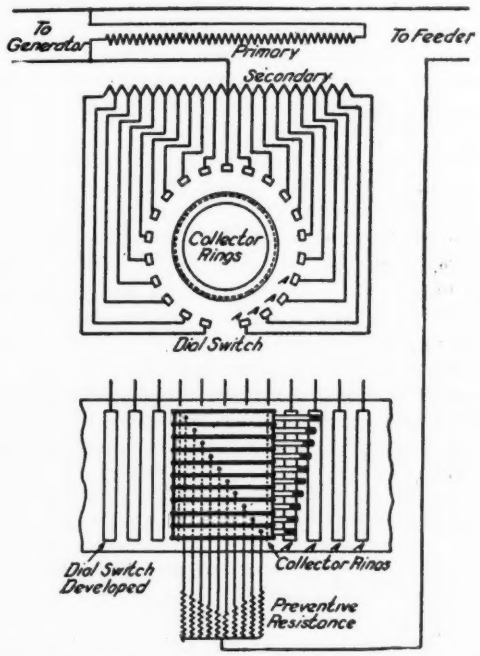


FIG. 9. SCHEME OF CONNECTIONS OF REGULATOR SHOWN IN FIGS. 7 AND 8

The dial switch 7 is for compensating purposes and functions exactly as does the compensating winding of a generator regulator. A "limit switch" is provided to release the clutch circuit when the regulator reaches the limit of its travel.

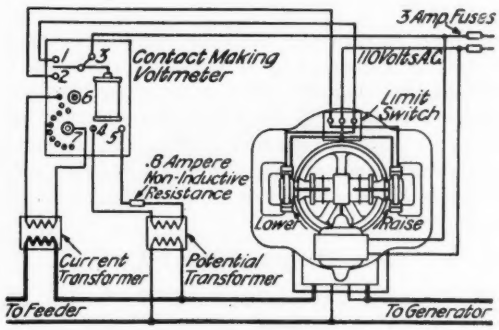


FIG. 10. DIAL SWITCH CHART ON REGULATOR SHOWN IN FIGS. 7 AND 8

If necessary, the compensating dial switch 7 can be left on the "no compensation" point, and line drop allowed for by means of external line drop compensators connected in series with the solenoid of the contact making voltmeter.

In some of the older switch type regulators, individual motors were not used, several switching mechanisms being driven from a small line shaft; regulation, however, was secured by clutches.

Compared to induction regulators, to be described later, the switch type has two advantages: First, it is slightly more efficient because it has in circuit at any time only enough secondary coils to produce proper voltage (thus reducing copper loss), while in the induction regulator the entire secondary is at all times in circuit; second, because of its light weight, the switching element can respond more promptly to impulses from the contact making voltmeter. In the induction regulator a large mass of iron must be moved against its own inertia and also against a magnetic pull.

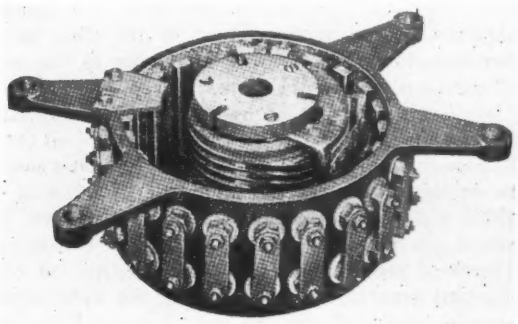


FIG. 11. CONTROL MECHANISM OF A SWITCH-TYPE REGULATOR

On the other hand, trouble with the switching mechanism and preventive resistances has led to a gradual abandonment of the switch type regulator in favor of the induction regulator.

(To be Continued)

Electric Method of Hardening Tools

A CURIOUS method of hardening tools, but one which seems to possess practical value, has become the vogue in Germany. In the process of electrolysis, the hydrogen generated at the cathode is heated to such an extent that the cathode itself is brought to a red heat. Advantage is taken of this phenomenon by using tools that are to be hardened as the cathode in an electrolytic bath. It is, however, necessary to protect the cutting edges of the tools, as these are liable to be raised to such temperatures that they become blunted.

Methods of effecting this are protected by recent patents of the Oesterr, Ung. Elektro-Schweissmashinen Ges. of Vienna. The cutting edges of the tools are covered with a layer of non-fusible conducting material. The thickness of this coating is so chosen that the edges are protected during the heating of the body of the tool, but so that, after the coating has flaked off, the teeth are exposed for the final heating. If the parts are only to be heated for subsequent hardening, the edges may be covered with graphite cement, so that the glowing tools may absorb carbon. Another method of protection consists in lowering the tool into coarse powder or sand, lying at the bottom of the bath, or the edges that are to be hardened may be protected from the influence of the current by covering the parts to be hardened with suitably shaped porcelain tubes, which are removed when the body of the tool is raised to the required temperature.

Automatic Induction Generator Plants*

TWO SMALL STATIONS OF THE SAN JOAQUIN LIGHT AND POWER CORP. OPERATED UNDER HEADS WHICH FORMERLY EXISTED IN THE FLOW LINE BUT WHICH HITHERTO WERE NOT UTILIZED. BY E. A. QUINN

WARTIME conditions, requiring such a vast amount of additional electrical energy, spurred on all central station companies in an effort to meet the additional demand and to forestall the threatened shortage of power. One result of this effort was the interconnection of the transmission systems of the hydro-electric companies in the state of California; divided into two groups, one including the group of companies in the northern part of the state and the other including the group of companies in the central and southern part of the state. Every effort was made to increase the output of hydro-electric energy, to decrease as much as possible the consumption of oil for fuel. The San Joaquin Light & Power Corporation's contribution to this effort was the laying of 22 miles of 6 in. welded pipe, having a capacity of 6,000,000 cu. ft. of natural gas per day, for use under the boilers at the Bakersfield steam plant, and the construction of two induction generator plants utilizing the water which is normally used through the San Joaquin River plants under heads which existed in the flow line and heretofore had not been used.

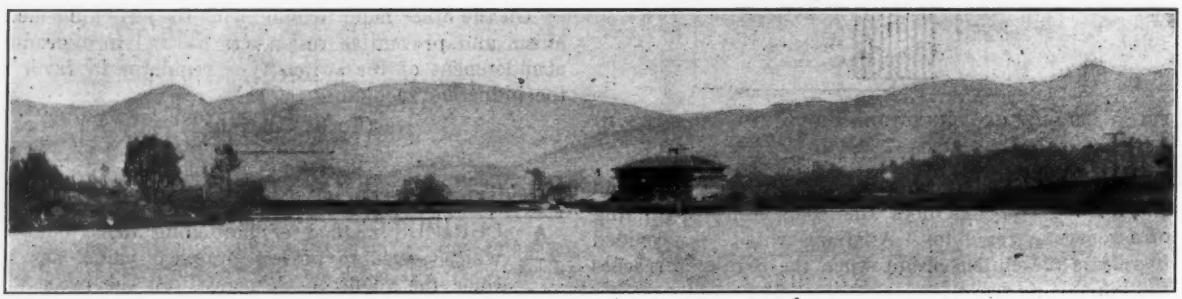


FIG. 1. POWER HOUSE 1-A LOCATED AT THE FOREBAY RESERVOIR

These induction generator plants are known as the "Crane Valley Power House" and "Reservoir 1-A Power House."

CRANE VALLEY DAM POWER HOUSE

THIS POWER HOUSE is installed just below the dam, and utilizes the head of the stored water, the maximum head being 120 ft., the minimum operating head 80 ft., and the wheel designed for best operating efficiency at 100 ft. head. Water is drawn from the lake through a gate tower connecting with a concrete lined tunnel 600 ft. long, 6 ft. high and 5 ft. wide. For a distance of 120 ft. a 48-in. steel pipe is concreted into the tunnel, the pipe tapering to 42 in. and then to 36 in., at which diameter it connects to the turbine. A hand-operated 42-in. butterfly valve is installed in the 52-in. pipe. Just above the butterfly valve the 48-in. pipe is used as a manifold having twelve 12-in. pipes and valves for allowing the discharge of the water into an intake basin at the head of No. 3 ditch, which permits of the bypassing of water through the ditch in the event that the butterfly valve is closed and the power house is shut down. The power house is built directly over the No. 3 ditch, the draft tube of the unit emptying into this ditch. A gate is installed further down the ditch below the power house so that the water from the lake can be used through the power house and either taken down the natural channel or down the No. 3 ditch.

The water wheel has a capacity of 1740 hp., and is of the left-hand single discharge type, operating at a speed of 450 r.p.m. The bronze runner is of the mixed flow reaction type, designed to withstand the maximum runaway speed that the unit can attain under an effective head of 120 ft. The wicket gates are so shaped that they tend to close if disconnected from the hand control.

The generator, rated at 100 kv.a., 2300 v., 3-phase, 60 cycles, is of the squirrel-cage inductor type, and is designed for 100 per cent overspeed. The unit is operated without a governor, but provisions have been made so that a governor may be installed should it be found desirable to do so.

Current from the generator is brought to a switchboard carrying an automatic oil switch, ammeters, voltmeter and integrating watthour meter. The speed of the unit is indicated by a voltmeter operated from a direct-current magneto belted to the generator shaft. The current is stepped up through three 400-kv.a. oil-filled, self-cooled transformers to 70,000 v., and is carried over seven miles of line, passing through a 70,000-v. automatic oil circuit breaker where it connects to the main transmission line.

POWER HOUSE 1-A

THIS POWER HOUSE is located at the forebay reservoir at the head of the penstock for No. 1 Power House. The 3½-mi. conduit which carries the water from the discharge at No. 2 Power House to the No. 1 Reservoir ends at a point which has an elevation of 42 ft. above the high water level in the reservoir. The water was carried through 1100 ft. of flume from the ditch to the reservoir, and it was decided to utilize this head by paralleling the flume with pipe and constructing a plant to operate on the flow of water in the conduit.

The unit consists of a 600-hp. end-inlet single-runner, double-discharge, mixed-flow reaction turbine operating at a speed of 240 r.p.m., the runner and shaft being de-

*Abstract of Engineering Committee Report of the Pacific Coast Section of the N. E. L. A. Reprint from the Journal of Electricity.

signed to withstand the runaway speed which can be attained under an effective head of 39 ft. The casing is of riveted sheet steel, cylindrical in form. The wicket gates are of such shape that they tend to close if disconnected from the hand control. The turbine is direct

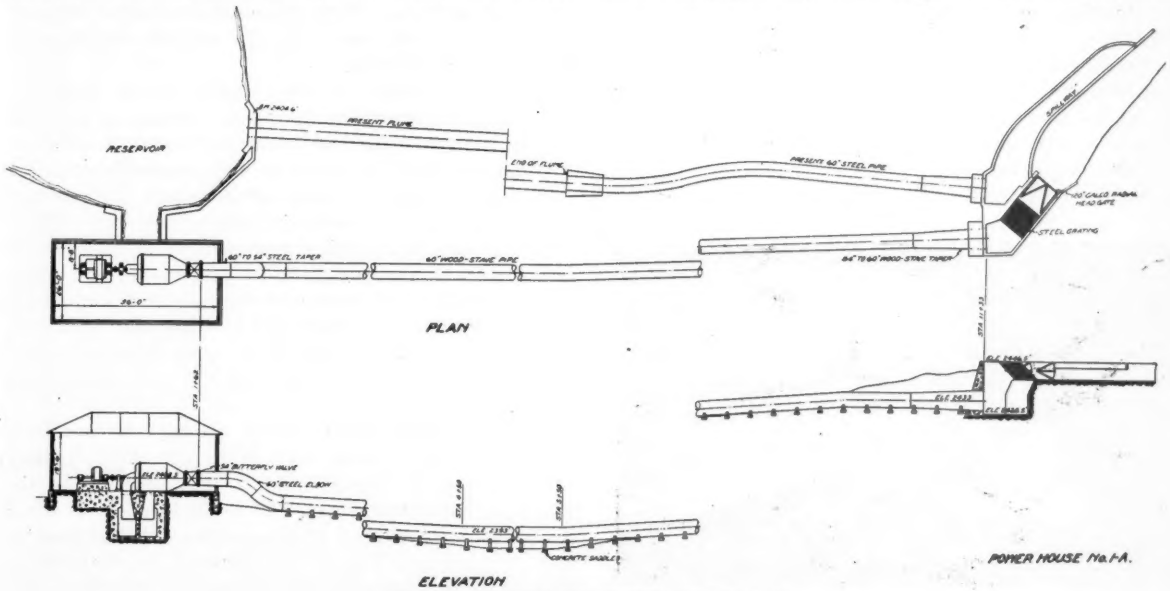


FIG. 2. DETAILS OF POWER HOUSE 1-A

connected to a 425-kv.a. squirrel-cage inductor type generator; 6600-v., 3-phase, 60-cycle, designed for an overspeed of 100 per cent. The unit operates without a governor. Current is brought to a switchboard upon which is mounted an automatic oil switch, voltmeter, ammeters and integrating watthour meter. The speed of the unit is indicated on a direct-current voltmeter

wheel shaft. The staves are 2½ in. thick and the bands ⅝ in. in diameter; the band spacing having a safety factor of 5, and the bands having a tensile strength of from 55,000 to 65,000 lb. per square inch. The upper end of the pipe is tapered through a length of 25 ft. from 84 to 60 in., and the connection to the butterfly valve is made through a steel pipe tapering from 60 to 54 in.

As the quantity of water flowing may vary from time to time, it was found necessary to devise some means of controlling the opening of the wickets to compensate for the increase or decrease in the amount of water in the ditch. This is effected through the means of a float

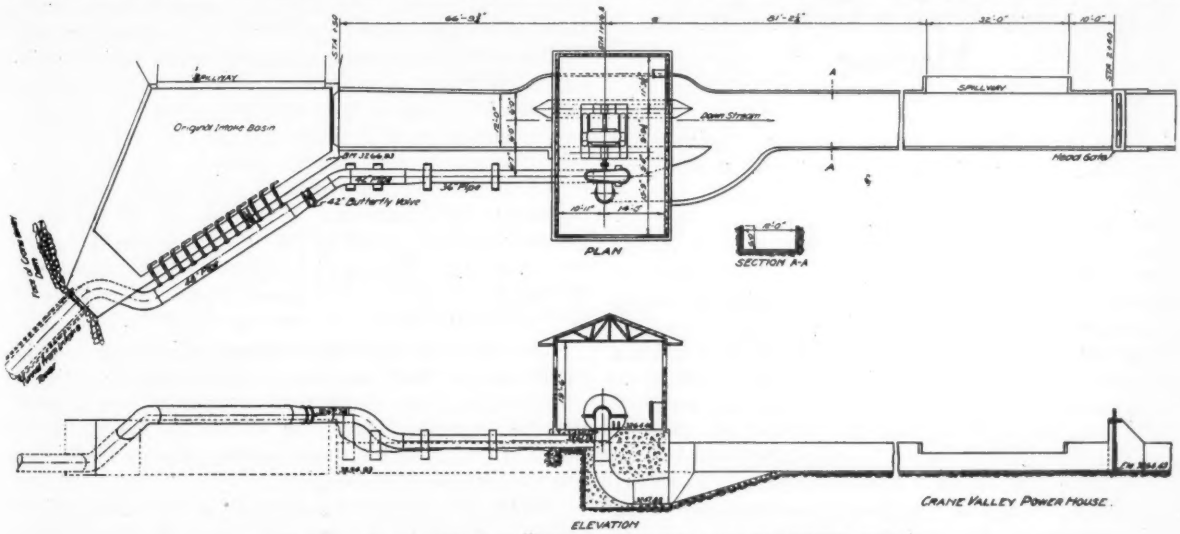


FIG. 3. PLAN AND ELEVATION OF CRANE VALLEY POWER HOUSE

actuated by a magneto generator belted to the generator shaft.

At the end of the No. 1 conduit a forebay was constructed, from which is taken a 60-in. redwood stave pipe 944 ft. long. It is in the form of an inverted siphon, the lowest point being 15 ft. below the center of the water

switch in the ditch which operates a motor on the turbine wickets in such a manner as to keep the water in the conduit at a constant level over the intake of the pipe.

An automatic spillway weir was connected in the conduit so that in case the unit is shut down the water spills over this weir and is carried to the reservoir

through the existing flume and pipe line, thus bypassing the plant and eliminating any waste of water. Should the machine trip off the line and increase in speed, a centrifugal switch on the shaft of the unit closes a circuit on the wicket gate operating motor, closing the wickets and shutting down the machine. The water in the ditch immediately starts to rise, and flows over the weir bypass until such time as the caretaker of the plant arrives and puts the machine back on the line. The float on the control operates to keep the water at a level just below the weir spilling point.

These power houses are operated without attendants, the regular dam tender and reservoir tender making visits to the plants from time to time. An alarm system is installed in the caretaker's cottage so that he is notified if the machine is tripped off the line. The machine, in the meantime, may attain runaway speed.

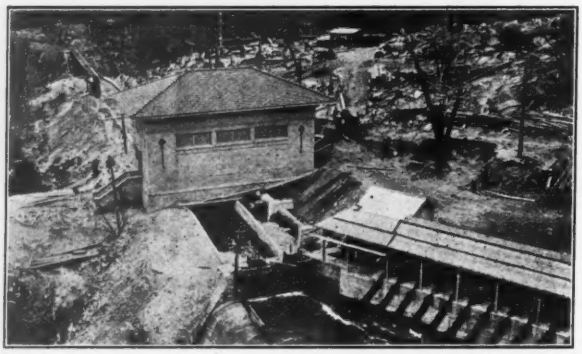


FIG. 4. CRANE VALLEY POWER HOUSE SHOWING MANIFOLD DISCHARGE PIPES AND SECTION OF DITCH

Experience With a Dense-Air Ice Machine

By C. H. Willey

IN a country club where a three-ton Allen dense-air ice machine had been installed to supply cool drinking water, a daily supply of 350 lb. of ice and the cooling of the storage rooms, I was called to find out why the machine would not work properly. In spite of all efforts of the man in charge, the machine would not build up sufficient pressure in the system. Upon asking questions, the operator told me that about a month ago when they were giving the machine a general overhaul and had the expander piston out to smooth up some scores in it, when they replaced it the machinist failed to tighten it securely in the crosshead and it gradually worked out until it drove out the cylinder head and cracked the cylinder. A new cylinder was obtained and installed, but when the machine was started it would not even frost the pipes. After considerable hunting and puzzling, the engineer decided that the expander valve was to blame and that by changing its setting he could make it run right. So he took out the valve and added on 3/16 in. to each end. Then he put it back and the machine seemed to do better for a while. Finally it got worse, and at this stage I was called.

I checked up the valve settings and immediately removed the built-up valve and plugged the screw holes where he had added the pieces, then set the valves according to the maker's directions for a three-ton machine, which measurements for the expander cylinder are: Lower valve, 1/32 in. lead; upper cutoff valve, closes or cuts off at 6¼ in. With these settings and a properly designed valve obtained from the makers, the machine would operate all right.

It seems so foolish to think that anybody would attempt to change a valve length or design, or for that matter, any other part of a machine which is designed and manufactured by experts, and especially so when one stops to realize that several thousands of these machines have been sold and are highly satisfactory. Many troubles could be avoided if operators of these dense-air ice machines would give them the proper care and study out the principle of their operation so that they could more readily trace a trouble and hit upon the right solution. The writer, who has given some thought to and for 8 yr. has operated these machines, therefore hands on these pointers.

These machines when started up take the air from the atmosphere through what is known as the primer pump G, and gradually build up the pressure in the system to five atmospheres, (60 to 70 lb.). It is when the system is so charged at this pressure that it does its work of cooling. This is the pressure in the system. This air is then taken by the compressor cylinder B and compressed to 210 to 240 lb. (a ratio of 3 to 1 being about right between pressures). Compressing the air heats it. Heat that is stored up by the labor expended upon compression is partly removed by passing it through a copper cooling coil C immersed in circulating water, which reduces the temperature to nearly that of the water. Cylinder CC is a cooler which further cools the compressed air by the cold air returning from the refrigerated rooms. The air then passes into the valve chest of the expander D, which is in construction very similar to the usual steam engine equipped with the riding cutoff valve. The valve admits the compressed air (210 to 240 lb.) upon the piston of the expander cylinder to a certain point of the stroke, about 1/3, and then cuts off. The piston continues to travel to the end of the stroke, the air exerting pressure upon it which constantly diminishes by expansion. This takes out of the air a quantity of heat equal to the labor performed by the air expanding. The result is a very low temperature at the end of the stroke. The return stroke pushes the cold air out into the system at a pressure of 60 or 70 lb.

The expander D helps the steam cylinder A and the compressor B takes the power. The expander cylinder cutoff valve must cut off the pressure at such a point that the expanded air at the end of the stroke of the piston is very nearly the same as the pressure in the system out into which it pushes it.

Many troubles can be avoided in the operation of dense-air machines if they are given the proper care. A few points on their operation that will help are given here.

Do not overtax the capacity of the machine. The amount of piping used in refrigerating the storage boxes of rooms should be such as to give about 1 sq. ft. of outside surface of piping to 3 sq. ft. of interior room surface (ceiling, sides, and floor, interior divisions not

counted) for the rooms which the cold air enters first. For later rooms 2½ sq. ft., and when a very large amount of room is to be cooled the last room should have about 1 sq. ft. of refrigerating surface for 2 sq. ft. of interior room surface. It is best to have the cold air enter the room first near the ceiling, especially in the later rooms, so the air currents may ascend to near the ceiling. The rooms that are to have the advantage in being kept cold should have the cold air first.

The two most vital points, to be sure, are first, that your circulating water through your coil (and water jacket around the compressor cylinder) is properly circulating. An item in connection with this is to see that this piping through which the circulation water is drawn and delivered to the cooling coil is well lagged, especially if it has to come through warm compartments, such as boiler rooms over boilers. Next, that when for any reason work is being done on any part of the system must be stopped in a permanent manner. Joints are generally made with thin rubber gaskets and the joint painted with litharge and glycerine. An occasional draining out of the bottom of the coils in the refrigerating room helps.

Once a year the whole piping system should be steamed out and then blown out. The machine should run at an average of 50 to 150 revolutions, according to the number of boxes or rooms being cooled or the volume of air being used.

All stuffing boxes on the machine piston rods should be well packed and kept tight. Be careful not to score the rods. Every tiny leak about the machine means loss of efficiency in refrigeration.

The piston leathers of the compressor and expander cylinders should last ordinarily about 2 mo. They can be resoaked in castor oil and when swelled used over again. There should be a steel forming die (similar

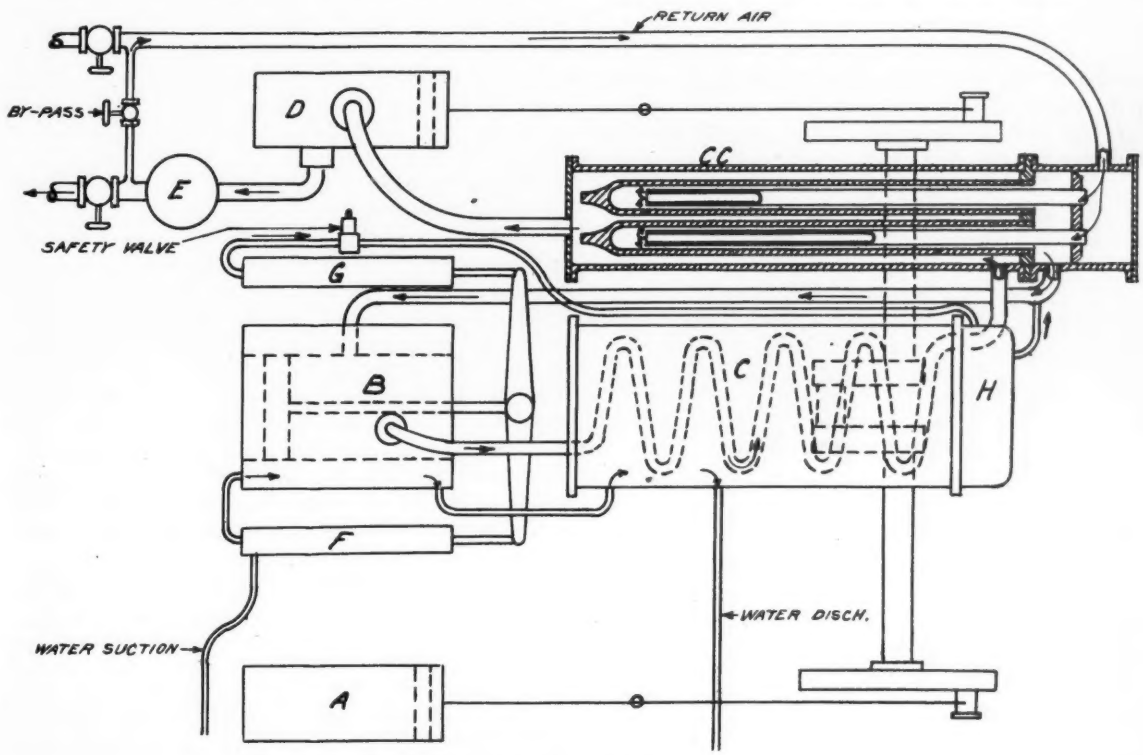


DIAGRAM OF DENSE AIR ICE MACHINE

or valve chests or cylinders, great care is given to keep the interior free from grit. A small scratch or score on the face of the compressor valve will vitally affect the proper working of the machine. These valve surfaces must be tight and a lubricator installed to give them an occasional drop of oil. The oil must be of ice machine class, able to stand heat and cold. A good mineral oil from which paraffin is removed by freezing is suitable. All joints should be carefully made, as air leaks do not take up, but get worse in time. Once every 3 mo. a pressure of 60 to 70 lb. should be put on the pipes, and every part of every joint, and every bolt head should be carefully inspected and tested by putting on a lather of soap with a brush, so that any leak will be easily detected by formation of air bubbles. These leaks

in construction to the piston in which the cup leathers are used), in which a spare set of leathers should be tightly clamped and formed. This die with the leathers in should be submerged in a can of castor oil. This treats the working edges of the leather to a soaking bath in the oil and keeps the main part of the leather that is clamped in the die or on the piston dry, the feature of this being that when the spare leathers are placed in use in the machine they will not require constant following up to squeeze out the oil and take up the slack.

The leathers should be made from oak-tanned leather slightly less than ⅛ in. in thickness and cut ⅝ to ¾ in. larger in diameter than the cylinders, according to size. When these leathers give out, trouble will be experienced with a loss of pressure. Sometimes the high pressure

decreases in relation to the low, and sometimes just one cylinder may lose pressure and the system shows a loss of cold.

The clearance of the setting of the primer pump that makes up the air leaks is also a very important item. It should be the very least possible with regard to safety in striking. About 3/64 in. is right. The clearance in any of the cylinders of the air part is very small, so that little change is permissible in the wearing parts and they must be frequently checked up. When removing and replacing the nuts on the piston rods when putting in leathers, the unscrewing of the rod or the least movement of it in its crosshead must be guarded against. I think the change of these small clearances is the cause of the breakage of many cylinder heads that I hear of from time to time.—REFRIGERATION.

The Diesel Engine---II

ATOMIZATION OF FUEL; FUEL INJECTION; AIR SUPPLY. BY HERBERT HAAS.

AS has already been explained, highly compressed air is used for atomizing the fuel oil; incidentally it serves the purpose of injecting the fuel oil into the cylinder during the process of atomization. In the atomizing nozzle of the fuel valve a part of the pressure of the injected air is changed into velocity, which reaches its maximum at the orifice of the nozzle. Owing to the expansion of the air at the orifice there is a decided drop in temperature at this point, where the ignition of the fuel is to be initiated. This localized lowering of the temperature at the nozzle orifice is accentuated during periods of low load, when the fuel supply is diminished proportionately to the engine load, whereas the injection air supply remains constant; that is, the same as at full load, because the fuel-valve needle stays open during 10 to 15 per cent of the stroke of the engine, irrespective of the load. The relation of fuel supply to air supply is therefore changed with a change in load. It is consequently more difficult to initiate the ignition at partial than at normal engine loads.

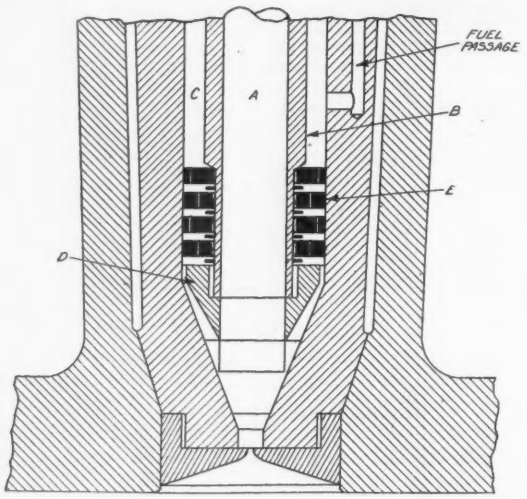


FIG. 3. ELEMENTS OF A COMMON TYPE OF ATOMIZER

The elements of a common type of atomizer are shown in Fig. 3. It comprises a fuel needle *a*, guided for a great part of its length in a cylindrical barrel *b*. The needle and the guide are carried in a flanged cage, which is slipped into the central passage in the cylinder head and is bolted to the latter. The outer diameter of the needle guide is smaller than the internal diameter of the cylindrical valve cage. The annular space *c* thus formed around the needle guide is connected with the injection air receiver and is at all times filled with compressed air. The needle guide terminates and seats against a corrugated cone *d*, provided with about 20 slots, each 1/16 in. wide. The cone fits the cone-shaped end of the valve cage. Above the cone are a number of perforated plate rings, *e*, so placed that the perforations of each succeeding ring are staggered with regard to those in the ring above. Each ring is provided with 18 to 20 apertures 5/64 to 3/32 in. in diameter. An atomizer tip is screwed over the end of the valve.

The needle valve is held against its seat by a powerful spring, provided with a suitable spring cap, a bonnet, and exterior adjusting nuts. In the body of the valve an oil passage is drilled to deliver the fuel on top of the perforated rings. In other types, to avoid the cost of drilling these long, small passages, two concentric spaces are used—the inner for air, the outer for fuel—formed by inserting a cylinder over the needle guide, thus dividing the annular space around the guide into two compartments. Holes in the bottom of this cylinder permit the fuel to enter the inner air space and to be distributed over the perforated plates. The measured quantity of fuel oil proportioned to the engine load is deposited by the fuel pump in the fuel-valve chamber before the valve needle is opened.

The fuel oil is broken into innumerable small globules and runs from plate to plate and down into the grooves of the cone, and is distributed over and covers the surfaces of the plates and grooves, and a small quantity collects around the root of the fuel-needle point. When the needle valve is opened, the injection air sweeps this part of the fuel before it, propagating the ignition. The air attains its greatest velocity when issuing through the nozzle. The sluggish, viscous oil particles, being in a quiescent state, resist this sudden acceleration with their inherent inertia and move relatively much more slowly than the air. The rapidly moving air currents tear these particles to pieces, and when the air currents have attained their highest velocity at the atomizer orifice they nebulize the fuel. A small proportion of the fuel still remains behind and flows down to the top of the seat of the fuel-valve needle to initiate the ignition of the next fuel charge.

Fuel valves of this type require a change of pressure of the injection air with a variation in load. If the pressure and quantity of injection air were not reduced during periods of low load when the fuel quantity is much less, the air would sweep through the perforated rings and the cone and clean them of all fuel, leaving

none to accumulate around the fuel needle point. When the needle was opened the next time, the ignition might either fail completely or be delayed and cause a series of rapid, dull explosions. If the engine misses ignition, it will slow down, and the fuel pump will deliver an increased quantity of fuel oil, which will be ignited regardless of the high injection air pressure, but such speed variations and engine operation should be avoided.

A common way to carry the pressure of the injection air is by throttling down the air taken into the air compressor and adjusting it to the varying loads of the engine. This throttling must be done by the engine operator. The air pressure also has to be adjusted to the properties of the fuel oil, some oils requiring a higher injection air pressure than others.

In other engines provision is made for changing the height to which the valve needle is lifted. A lever is actuated to lift or to lower the fuel needle, and this lever is fulcrumed on a pin the journals of which are eccentric to the lever bearings, so that by rotating this pin to various positions, the length of opening of the fuel needle may be adjusted to the engine load. A small hand lever is keyed to one end of the pin and is provided with a "click" to hold the lever as set.

In large engines, especially those working with rapidly fluctuating loads, it is impossible for the operator to adjust the air pressure quickly enough to meet the constantly changing requirements of the engine. The work of the air compressor consumes 10 per cent and more of the power output of the engine. In large engines it is therefore desirable to proportion the volume of injection air to the engine load. This is accomplished by a patented design in which the engine governor influences not only the volume of the fuel supply, but also the volume of the injection air; the governor likewise affects the length of time during which the fuel valve is open, the period varying in proportion to the load on the engine.

Methods of Fuel Injection

To insure an unfailing correctly timed ignition of the fuel charge, Hesselmann, of the Swedish Diesel Engine Co., developed the fuel injector shown in Fig. 4. In this valve the fuel is admitted close to the end of the fuel needle. For this purpose the valve has two annular air spaces, connected with air passages at the top. The fuel is deposited in the bottom of the outer space and under the influence of the full injection air pressure is forced through a number of small passages, from the orifices of which it is swept off by the passing air currents in the inner space, as soon as the valve needle is opened. The fuel is in this manner thoroughly nebulized, and a small quantity left behind accumulates around the root of the needle point to initiate the ignition of the succeeding fuel charge with the opening of the needle.

In other forms of fuel valves, the same object is obtained by the use of annular fuel passages around the conical needle-valve seat, the oil in which is under the influence of the injection air pressure. When the fuel valve is opened, part of the pressure is changed into velocity; the resulting differential in pressure between the injection air that presses on the fuel and that which travels through the nozzle forces the fuel out of the annular passages through radial openings into the air stream, by which it is picked up and atomized. A small quantity of oil left around the needle point on the closing of the valve is used for igniting the next charge.

Fuel valves of this type permit considerable load fluctuations without necessitating appreciable change in the injection air pressure. They do not, of course, effect a reduction in the quantity of air used for injecting the fuel, which would be practically constant at all loads unless controlled by one of the methods previously described. In large engines, the saving of power effected by supplying only the required volume of injection air is important, although it necessitates adjustment to produce the most perfect ignition and combustion of the fuel. This consideration led to the automatic mechanical control of the injection air supply for large engines.

In the use of the fuel valves described, the fuel has to be pumped into the fuel chamber against the injection air pressure, which may vary from 40 to 70 atmospheres, the higher pressure corresponding to full load, so that the fuel pump must always work at a pressure appreciably higher than the injection air pressure. Such valves are also known as closed-nozzle valves, because the nozzle must be kept closed with the needle, except during the extremely short period of fuel atomization.

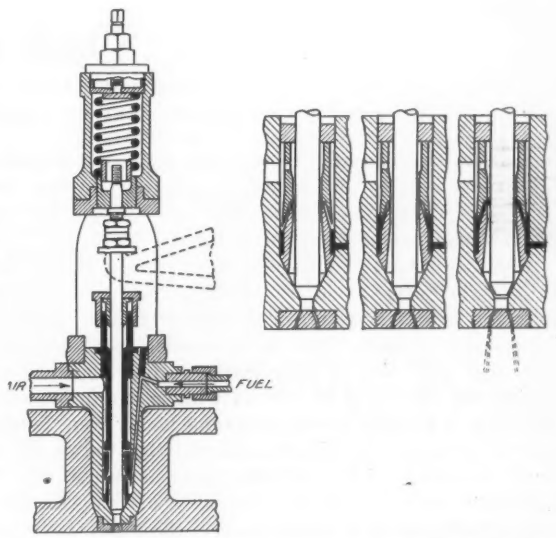


FIG. 4. FUEL INJECTOR DEVELOPED BY HESSELMANN

Another type of fuel valve, known as the open-nozzle type (also called the Lietzenmayer system, after its designer), uses an open fuel nozzle, as its name indicates. In fuel valves of this construction the fuel does not work against the high injection air pressure, but is subject merely to the small pipe resistance and low lift necessary to deposit the measured amount of fuel in a recess of the fuel-valve chamber in front of the open nozzle; this is usually done during the suction stroke of the engine, when there is the least resistance (pressure) in the valve chamber. When the time for the injection of the fuel arrives, a valve, similar to the needle valve above described, is opened, admitting the injection air into the fuel chamber; the air, in passing over previously deposited fuel, impinges on it, picks it up, and, forcing it into the atomizer, nebulizes it.

Regulation of Air Supply

The air supply to the fuel valves is regulated by throttling the discharge valve on the injection-air bottle, and the desired pressure, indicated by a manometer on the injection-air bottle, is maintained by correspondingly throttling the air going to the air compressor at the air intake.

Each bottle is provided with a cock and a drain pipe reaching to the bottom of the bottle to drain it of accumulated condensed water and oil.

For starting some engines low-pressure air is used (100 to 250 lb. per square inch), which is stored in the standard type of sheet-steel, riveted air receivers. The receivers are filled with air drawn from the injection-air bottle and supplied by the air compressor. In other engines the air receivers are eliminated altogether and a seamless steel pipe is used between the compressor and the fuel valves, the pipe taking the place of the injection-air bottle. A separate small compressor driven by a gasoline engine supplies the starting air. This practice lowers the first cost of the engine, but the absence of any air reserve makes it necessary that the compressor furnishing the injection air be of unfailing reliability. With the opening and closing of the fuel valves and the lack of sufficient receiver capacity the pressure fluctuates, and with an obstruction in the pipe the pressure may rise abruptly and burst the pipe, as even the precautionary blowoff valves can not be depended upon to act unfailingly. The presence of a gasoline engine with its highly inflammable fuel introduces a fire risk that is absent in installations that derive the starting air from the engine-driven compressor and have in the engine room only a small supply of fuel oil with a high flash point. This advantage of the Diesel engine should not be appraised too lightly in many industrial plants, such as textile and flour mills.

Odds and Ends

Ignorance, Prejudice and Custom Are Big Handicaps in Way of Cripples. By H. A. Cranford

HAS it ever occurred to you that while the amputations among the American soldiers, during the war, were under 4000, that there is a total of 26,000 every year in American industrial plants?

Recently we hear a lot about the reconstruction of the maimed and scarred soldiers, teaching them new lines of work and trades so they can be self-sustaining. This is the greatest of ideas. But let's consider those unfortunates that gave part of their bodies to feeding and furnishing the fine body of fellows with ammunition, etc., that made it possible for them to come home, even though they were wounded. Understand that my hat is off to every American soldier, whether maimed or not, and if those that are returning are the cause of the American cripple being given a better chance, then they have another honor besides winning the war; an honor that will be the means of helping an army in itself, 26,000 annually, to be self-supporting.

You will not have to reconstruct the crippled soldier. Simply give him a position, and let him work out his own salvation. Let him reconstruct himself, and while we are doing all we can for the 4000 let's keep in mind the annual 26,000.

The easiest thing to get into and the hardest thing to get out of, is a rut. This was brought to my mind very forcibly a few days ago. I interested myself in a one-armed man who was trying to land a job as millwright in a plant that a friend of mine was operating. When I called on my friend and made known my business I got a cold reception. He asked me who ever heard of a one-armed millwright. I asked him who ever heard of anyone flying across the Atlantic six months ago, but now it was a practical reality. Well, when our argument was over, he agreed as a personal favor to me to try the fellow out. He has been at work only a few days, but my friend remarked to me last night that his new millwright was turning out more work than anybody else he ever had.

My friend was in the rut. Custom had put him there, as it has many other good fellows. The average employer has always thought of sound men for his openings. He can't see how a cripple could do certain things. He overlooks the fact that it's a necessity that the cripple find out the how and why of things; that he is studying that very thing all the time in order that he may be self-supporting and independent, and if given the chance at any job that he thinks he can hold, it's a safe bet that he will find the way to do anything connected with that job.

Just a little more about ruts. I was visiting a chief engineer in a certain plant a short time ago, and while we were talking one of his oilers came in and called his attention to some condition that existed in a part of the plant with which the oiler had nothing to do. The chief looked the oiler over slowly, and made this remark. "If you expect to make a success here, Charlie, just attend strictly to your own affairs and department, and let the other fellows alone."

That may be good advice, but I don't believe it. I can't think that a fellow would be a howling success if he took interest in nothing but his own affairs. To say the least of it, I would hate to think that there was nobody interested in my affairs, or that I was taking no interest in the other fellow's affairs. A man would become so self-centered that he would find himself in the proverbial rut, and the only advantage that a man who thinks only of himself could have is that there would be so little on his mind that he wouldn't suffer from mental fatigue very much.

When I heard this chief make this remark to the oiler I started a little investigation. I found out that he had been in the present position for about 18 yr. His salary was about 60 per cent of what it should be. He is getting the same he got 10 yr. ago. He has no use for trade organizations, cares very little for trade journals, and none at all for text-books. Says that he "believes in every tub standing on its own bottom." The thought struck me that his "tub" must have a pretty weak bottom, if it didn't support more than a $135 per month salary, after almost a generation of service.

This man is in a rut and every unit in the plant is a

mute witness to this fact. He believes in custom. He has a set way of doing things. Let me tell you that I believe that the engineer or employer who comes to his office in the morning without his mind made up to reverse all former decisions or methods at a moment's notice is riding for a fall. This old world has been changing so fast in the last three years that conditions remain the same hardly 24 hr. and to meet these rapid changes a man must be a mental acrobat. I know that I have had to cut mental double somersaults in every conceivable direction to meet the whirlwind changes in conditions.

After visiting the chief who was in the rut, I visited another one that was *not in a rut.* I saw on his desk Power Plant Engineering, Power, Southern Engineer, Electrical World, and The Motor World. Everything in the plant was spick and span. He has been with the concern 10 yr. His salary is exactly 100 per cent more than it was when he started. He is a union man and proud of it, and he attends the meetings. When questions come up he takes part in the discussions. His brothers like him. His helpers like him, and his employers bank on him. He attends to his own affairs thoroughly, but still has time to help his assistants to progress, and when they are ready he coaches them for their examination, and then helps them get better positions. He is a hard worker. His friends often tell him that he will soon wear out. His reply is that "he would rather wear out than rust out."

I doubt whether he will wear out as soon as the fellow in the rut. It takes more energy to drive an automobile in a rut at a slow rate of speed than it does on smooth roads at a faster clip, and it's a lot harder on the tires in the rut, and when you try to get out you sometimes break down entirely. There are just three things that will put us in the rut, according to my way of thinking: ignorance, prejudice, and custom.

The cripple has to deal with ignorance on the employer's part, and educate him to the fact that cripples can do what they want to do. I do not think that anybody could be prejudiced against a cripple. Then he has to fight old custom. And that is the hardest proposition.

Instead of telling from time to time how a one-armed man does certain things around a plant, I am just going to tell WHAT he does from time to time, and then if there is any reader interested in how it was done I will answer any inquiry and go into details.

A few days since, I wanted a partition built across the engine room. There is so much work going on here that it's almost impossible to get carpenters or any other members of the building trades. This partition was to be 10 by 20. Of 2 by 4 framing and tongue-and-groove flooring, I built it without any assistance in 6 hr., and made it practically air-tight.

Recently, I installed metal molding in a room 20 by 20. I cut and fitted the molding on the ceiling, hung four drop lights and put in a switch in 5 hr. without any assistance.

I can use a wheelbarrow, drawing knife, brace and bit, etc., and do not use any artificial appliances. At first I did; but I soon discovered that they were more or less in the way when not actually in use, and that I could study out a way to get by without them. The only thing that bothers me is using a punch or chisel. But I wouldn't work on a job where they would not allow a helper to do the striking when such work is to be done, which is seldom. I hold the chisel and let the helper strike. Some will say that this is risky. Well, I have had my hand struck only three times in 13 yr., and I'll guarantee that there isn't a two-handed man that's done as much chipping as I have that hasn't struck his own hand more than that number of times. A helper will be too careful at first, but I talk to him until he gains confidence in himself and we get along as fast as is desired. He can watch where he is striking, while a man both holding and striking has to watch his work.

A man with part of the forearm left can do anything he wants to do, if he believes in himself and won't let people pity him. After all,

If you think you are beaten, you are;
  If you think you dare not, you don't;
If you'd like to win, but think you can't,
  It's almost a cinch you won't.
If you think you'll lose, you've lost;
  For out in the world you'll find
Success begins with a fellow's WILL;
  It's all in the state of the mind.

THE UNITED STATES SHIPPING BOARD announced recently that arrangements have been made by the Board's recruiting service to provide vacation jobs in the Merchant Marine for American College students. By these arrangements, graduates of colleges and high schools are permitted to take license examinations as third mates after they have put in one year of sea service.

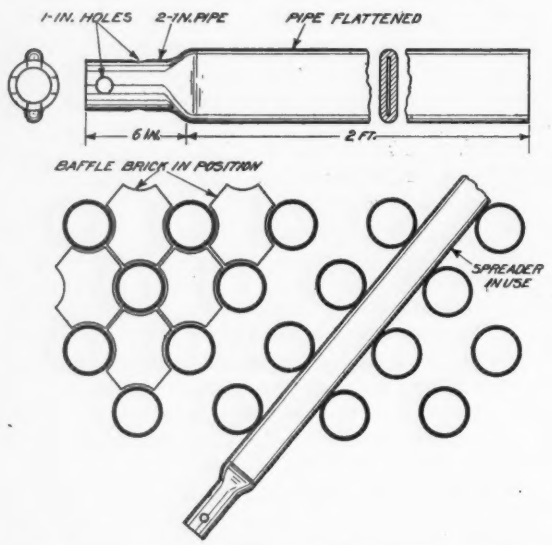
Under a special ruling of the Board students may be taken on during summer vacations, the Board requiring them to sign on for one year of service, but giving them a furlough at the end of each vacation so as to release them for their studies until the ensuing vacation. The vacations thus spent at sea count in their service record, and a student entering the service during the vacation following his freshman year, would have only three months to serve at sea after graduation before he becomes eligible to go up for an examination for the immediate granting of his third mate's license.

Induction to seagoing life must be on a training ship of the United States Shipping Board Recruiting Service, where for the first two months the students will be rated as apprentice seamen and receive pay at the rate of $30 a month. During the third month they will be sent to sea on merchant vessels with the rating of ordinary seamen and will be paid at the rate of $55 a month. Other vacation or post graduate service will be put in upon vessels making voyages to the various ports of the world, as the Shipping Board wants the college sailors to visit the great cities and marts of other countries during their training period, and they will receive every encouragement to make a study of foreign trade conditions with a view to their future employment and usefulness in the shipping business after they have acquired a practical working knowledge.

DON'T LET careless expenditure make a sieve of your purse. Buy wisely and increase your money holdings by investing in W. S. S.

Repairing Vertical Boiler Baffles

A BABCOCK & Wilcox baffle wall is built of fire brick with a cast-iron wall placed behind to support it. The cast-iron section is in two divisions, one running on an angle left to right, the other from right to left and bolted top and bottom with ¼ by 1¼-in. bolts and washers, the result being a solid support wall for the fire brick. When the fire brick crumbles from age or other reasons, it leaves the iron bare, which causes the bolts to become burnt and fall out. Next, the cast-iron baffle starts to burn at the base and curl; result—a larger hole. The gases, naturally taking the shortest road to the stack, rush through here, so that it is really getting the brunt of the heat of the fire. Any engineer can readily understand what the loss of all this heat means. Another result of those leaks, especially on the Webster style furnace, is that the support bars for the baffle wall are burnt in two, completely destroying them.



FLATTENED PIPE AND ITS USE FOR SPREADING TUBES

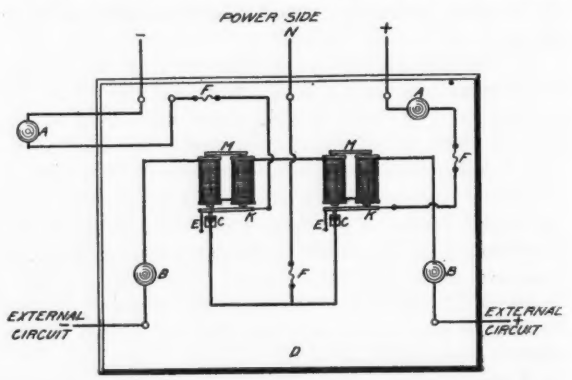
A remedy for nearly every case of this is as follows:

Heat a good piece of 2-in. seamless pipe, about 2 ft. 6 in., in the fire for about 2 ft. up, then hammer it down until it resembles the sketch. Next, drill two 1-in. holes straight through, about 2 in. apart, put a pin or bar through to turn with. This article is commonly known as a spreader. Let the man slide this up between the tubes as shown in the sketch. Two or three tubes must be taken; for instance, if only one brick is to be replaced in the bottom row, let the spreader be placed two up, and if two or three need replacing, shove spreader up for three tubes, the idea being, the more tubes held, the steadier the spreader will be in place. Care must be taken to place the tool as near the baffle wall as possible, leaving enough room for the man to do his work at the same time. A very important matter is to see that the spreader is turned square as possible, for, if left on an angle so that the pressure of tube will snap it back flat when a man has his hand up between, the result is likely to be a badly bruised or broken hand, as the spring on the tubes is considerable. When, on removing old material, a baffle iron is found burnt off, let the man who is doing the work get an old flat piece of iron. When placed in position, be sure it is not too broad, because it will dent the tubes that lie on both sides of it when they are allowed to settle back in their position. Better still, there may be some old flame plate (baffle iron) lying around which can be broken to fit, then he can easily place his brick. But this must be remembered, that there is no use in placing brick without something behind them, as they will fall shortly after the boiler is in operation, and the time and labor is only wasted. A little chipping on the grooved sides may help a lot where the tubes are bent and bricks hard to get in, and if he finds he cannot get his 2-in. pipe spreader up, let one of 1½-in. pipe be made and used for a leader for the 2-in. spreader.

E. DUFF.

Circuit Breaker Indicator

WHILE operating a power plant in which the engineer had to be out of the engine room some of the time, there was some inconvenience caused by the circuit breakers on the switchboard blowing out and not being observed until a messenger was sent from the shops to notify the engineer.



CONNECTION DIAGRAM OF CIRCUIT BREAKER INDICATOR

From this it was natural that the idea of some form of an alarm should spring up, and I mentioned the fact to the instructor of the electrical laboratory and asked

him if switches operated by magnets could not be utilized. At the same time I stated that the magnets would have to be wound to take a voltage of 220 v., which was the potential used on the power lines. He agreed with me that the idea was feasible and said that they could have some of the students wind the necessary magnets as a part of their class work.

As the time never came to have this done, an assistant instructor devised the arrangement as shown herewith, by using bell magnets and, while I am not saying that this is the best form for such an alarm, I think that it will be interesting to readers.

It will be seen that the magnets, M, are such as are used on small electric bells and these are connected in series across the two outside lines of the system, with the lamps, B, so that about ½ amp. of current would flow through them. The keepers, K, were made of light pieces of iron with a flexible joint at the fulcrum end. Light springs, E, were connected to the opposite ends so that they would press firmly on the contact points, C, which were adjustable.

The working of the arrangement was as follows: With the circuit breaker set and the current flowing in the outside line, the magnets, M, would be energized and the keepers, K, would be held up to them and no contact would take place at C. The lamps, B, would be mounted on the panel, D, and would burn all of the time, which would indicate that the circuit was complete through the magnets.

If the breaker went out, the keepers, K, would assume the position shown in the sketch, and when contact is made at C, the circuit is completed between the generator side of the breaker and the two signal lamps, A, which would light and remain so until the breaker is closed. These lights could be placed at any point in the plant, and the intention was to have them colored so as to be noticeable.

In the same way, a bell circuit could be arranged to ring alarm bells if preferred.

The panel, D, was made of heavy asbestos board. F, F, F are fuses, of which any form can be used, and it would be advisable to have the magnet circuit fused and cut-out switches might be of advantage.

One advantage of such an arrangement is that there is no need of connecting anything to the front of the switchboard, as everything can be concealed in back.

G. H. KIMBALL.

Overcoming Heater Float Troubles

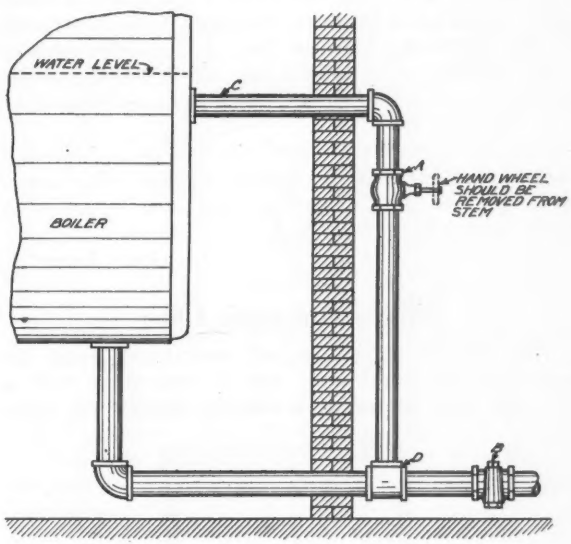
THE LETTER by New York, Overcoming Heater Float Troubles, on page 648, July 15 issue, has been noted. It seems to me that conditions being as stated, the new arrangement, shown by New York, will also give trouble at times.

It is stated that the float in the old system sometimes collapsed; this could happen only if there was considerable pressure on the chamber containing the float. If this happened with the 8-in. cylinder arrangement, that is, the pressure on the hot well, water would be blown out the top cap around the rod which is open, as the arrangement would not work if a stuffing box were there, causing an air-tight compartment at the top of the chamber holding the float. If a vacuum was formed in the hot well, the water might be drawn from the 8-in. cylinder. With either a vacuum or a pressure in the water compartment of the heater (which would be quite possible if there is a back pressure, or relief valve, between the heater and the atmosphere), the water valve would not be operated properly by the float. It seems to me, however, that all danger of wrong operation would be overcome if a top, as well as the bottom connection, from the 8-in. chamber to the hot well were added; this would act as a pressure equalizer. If there is an open pipe from the heater to the atmosphere, the arrangement with the outside chamber will work, but how can this be if the floats inside the heater become flattened, or, as New York puts it, collapsed? It will be necessary to add a packing box to the top of the 8-in. pipe cylinder, containing the float, if a top connecting pipe is added, and pressure in the heater water chamber.

JAMES ELLETHORN.

Protection For Blowoff Pipe

PROBABLY there is nothing original in the following observations, the result of noting the letter on blowoff pipe covers by L. A. Cole, Page 651, July 15 issue.



COMMON METHOD OF CIRCULATING WATER THROUGH BLOWOFF CONNECTION

Many of these coverings have been suggested by different writers in technical journals for many years past. They are of all kinds, from the simple fire clay plaster to the elaborate sectional detachable affair, factory made.

One point I fail to understand in the cross section of the covering shown by Mr. Cole. What prevents the end of the bricks from coming down and resting upon the horizontal pipe? He states that when doing any repair work, the brickwork is taken down and in rebuilding it, no mortar (fireclay, I suppose he means) is used. To my mind, it seems that such an affair would get knocked down every time a combustion chamber is cleaned out, unless cleaners are a good deal more careful in moving themselves and their tools around than most of that ilk.

Mr. Cole says that more or less cold air is drawn in around the blowoff pipe into the box, which helps to

keep the pipe cool. It looks to me as if the joints between the bricks, being open (clayless), the air will do more harm than good; in fact, help to burn the pipe, as it is absolutely impossible to lay bricks in the manner described without leaving the joints so that hot gases cannot get into the box.

The old reliable way to connect up a blowoff pipe is with a circulating pipe connected as shown, the pipe, C, being below the water line. When blowing down the valve, A, is closed. An improvement is to have a valve between D and the brick wall; closing this valve pipe, C, will act as a surface blowoff. Of course, a valve must also be attached beyond the tee, D, as at B.

Unless the boiler water is uncommonly dirty, no covering whatever is required on the blowoff pipe; there will be a constant circulation of water through the pipes as long as there is fire in the furnace. Of course, like everything else in engineering, any fool can close the valve and stop the circulation; he can also screw down the safety valve if he is built that way.

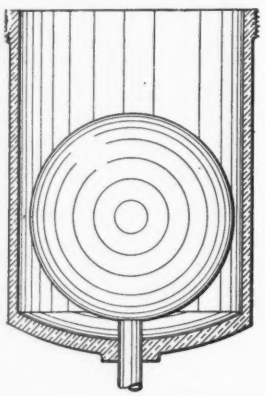
One thing should be remembered: All blowoff piping should be extra heavy steam pipe, with the end openings reamed out full. With the blowoff piping connected, as shown in my sketch and the boiler blown down as often as the condition of the water warrants, there is no need of covering of any kind; in fact, it is an improvement to be coverless, as any slight leak can be noted and the pipe can be given the hammer test at the regular monthly clean-out.

I have heard about covered blowoff pipes becoming badly corroded from the outside without being noted until they were in a dangerous condition, the corrosion being caused by a small leak at the thread.

JOHN THORN.

Simple Automatic Oiler

WE HAD in service an old centrifugal pump for emptying our sump tank, and it was fitted with a very old type of babbited bearing without oil reservoirs. As a result, it was difficult to maintain proper lubrication, without waste; and as it was used only occasionally, it was not deemed advisable to spend much money in renovations, or any new oiling device. We finally arrived at a satisfactory solution by taking two large oil cups which were in the store-room and attaching one to each bearing. Then in order to prevent the oil from running through to the bearing and wasting while the pump was standing idle, we placed two large balls in the cups in the manner shown in the sketch, the idea being that when the pump was idle and motionless, the ball would effectively cover the oil outlet and prevent the running out of the oil; while, as soon as the pump was started up, the vibration attendant on its operation would agitate the ball and allow the oil to drop through to the bearing. In this simple way, an automatic oiler was secured with no expense for new equipment.

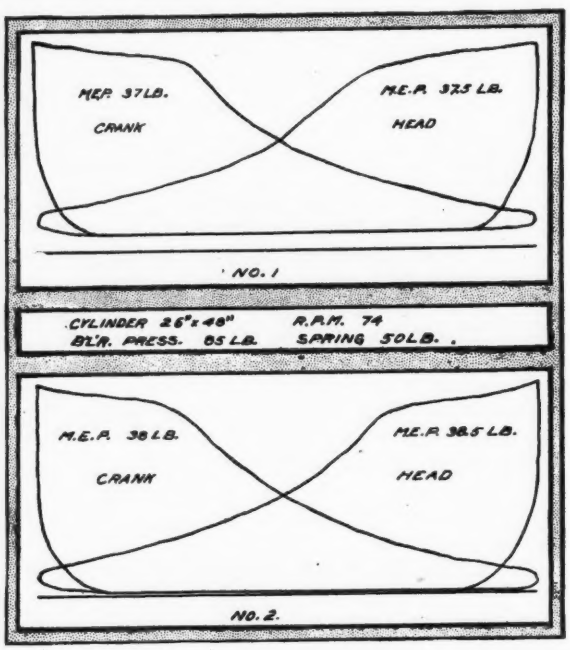


AUTOMATIC OILER

M. A. SALLER.

Effect of Increasing Back Pressure

HAVING NOTED the letter of Receiver in the June 1 issue, relative to increasing back pressure and fuel conservation, I wish to submit two diagrams of an Allis-Chalmers Corliss, 26 in. by 48 in., speed 74 r.p.m. Diagram No. 1 was taken with the back pressure on, while No. 2 was taken with the atmosphere valve open, as at this time the exhaust was not needed.



CARDS TAKEN BEPORE AND AFTER REDUCING BACK PRESSURE

The load increased a little when No. 2 was taken. These two diagrams are illustrative of the effect of back pressure on the engine, as with back pressure the terminal pressure will naturally be higher, with a consequent increase in steam consumption per indicated horsepower-hour.

J. C. K.

Proper Buying and Handling of Boilers

INSURANCE rates on boilers would be much lower and replacement costs also much smaller, if general industrial firms followed the same methods as those used by a textile mill at Henderson, Ky., namely the Henderson Cotton Mills Co. This company believes in taking care of property, and installs the best obtainable

regardless of cost. Its methods are really unique, but its records show that they are correct.

Fourteen years ago the company remodeled its power plant, the mills having been established nearly 40 yr. ago. At that time 12 horizontal return tubular boilers were installed, although but ten were required to run the plant. In installing these boilers the company did not merely enter the open market and buy boilers, but purchased the material, and had its boilers tailor made, or to order. The company accepted bids on the steel plate and accepted what it considered the best all around specification bid. It then went to an insurance company and hired an inspector at $20 a day. This man inspected the boiler plates as they came from the rolls and stamped his inspection in each sheet, turning down more than 60 plates before securing the quantity specified. Each plate was carefully inspected, and approved, with the result that the plates were right to start with.

Next the company went to a reputable tube company and purchased its tubes, each tube standing a rigid inspection from a paid inspector from the insurance company. A contract was entered into with one of the large boiler manufacturers to make up the boilers from furnished plates and tubes under specifications furnished by the insurance company, and another inspector received $15 a day while inspecting the setting up of the boilers. Every rivet was inspected before and after it was driven home. When these boilers were completed, there were no better boilers of the type to be found anywhere.

After getting the boilers into the plant, the same methods of careful handling were used. The boilers were needed to handle the full load of the plant, leaving two emergency boilers. All boilers were connected up in pairs, so that any two could be cut out. This enabled the company to give consecutively every pair of boilers a two day rest for cleaning and inspection. When boilers were cut out they were allowed to stand 24 hr. to cool out resulting in very little contraction of a nature that could cause damage. Lukewarm water was run in after the original water was removed, and that was allowed to stand 12 hr. The boilers were then drained, cleaned, filled and put back in service.

Boilers handled in this way should last a lifetime in any plant, provided they are good boilers to start with, as was the case here. Today there is not a blemish to be found in any of the 12 boilers. The company, however, is remodeling its plant, and increasing its horsepower with natural growth, resulting in the 12 old boilers being replaced with four of the vertical type, high-pressure, water-tube boilers, along with a 2500-kw. turbo generator. The new boilers are being built in the same way as the old ones, and the company has taken advantage of a strike in its plant to remodel the power plant.

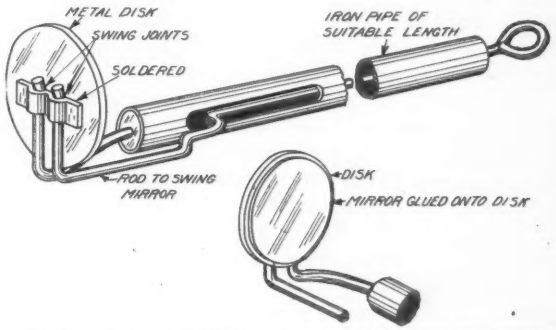
The condition of the old boilers is shown in a statement made by the agent for the insurance company at Louisville, who said: "These boilers are so good that we will re-write them today at 125 lb. working pressure, and would probably insure them at an even higher rate if requested, after making tests. The company had these boilers built to carry 150 lb. working pressure, although its actual load required but 105 lb., and it actually carried but 125 lb., its safety valves being set to pop off at that pressure. This greatly added to the lasting capacity of the boilers, gave the company a large excess capacity, and faster steaming proclivities, with less actual consumption of coal, as a boiler that is operated at considerably under its rated pressure will show better results."

The textile company has had a number of requests for its old boilers, several of which have already been sold, and at prices higher than the cost when installed 14 yr. ago, due to the general increase in values of boilers and machinery. There is no doubt that by conservative methods the company has secured much better results throughout the entire 14 yr., and still has assets that otherwise would have been charged off when sold for junk.

A. W. WILLIAMS.

Internal Bore Inspecting Device

THERE IS need for some sort of a device for aiding the proper inspection of the inside walls of tubes, pipes, small cylinders, rifle or cannon barrels, etc. Recently a home-made affair came to the writer's attention; this is shown in the accompanying sketches. The mirror is of



DETAILS OF CONSTRUCTION AND APPLICATION OF BORE INSPECTING DEVICE

good quality beveled glass. It is secured to the metal disk by gluing. This disk is moved back and forth by a small wire rod which is so bent that it is operated through a slot in the tube which is used as a handle for the device. The mirror is held into the end of the tube by the short bent piece of rod secured in a wooden plug. The tube is made any length required.

C. H. WILLEY.

Are Steam Traps Machinery?

THE ARTICLE by Mr. Haight under this heading, in the July 15 issue, certainly has "trapped" the trap question. Every engineer will realize that one who knows traps from A to Z has presented facts—real and pertinent facts—on the drainage problems that exist in every power plant, and that can be solved only by the use of steam traps.

Strictly speaking, traps are not machinery, though they do have moving parts and play an important role in the success and economy of plant operation. Whether it is a heating line, an exhaust connection, high pressure steam or engine drip, the water or condensed steam must be adequately removed, which means the installation of a trap that will handle the quantity of condensa-

tion in a period of time that will insure complete drainage under the service conditions. The trap must be large enough, respond to the flow of condensate, and be positive in action at all times. Of course, there are traps and traps, and then some! That is the real "rub" of the whole problem, causing confusion and dissatisfaction that often borders on disgust.

Who is at fault—the trap manufacturer or his salesman who sells the trap, or the engineer who practically ignores the all-important trap problem until some trouble develops? It is apparent that this question could stand quite some discussion as well as investigation, perhaps even the standardization on a proper capacity basis for each size of trap, based on the size of pipe connection.

While there are numerous makes of traps on the market, there are only a scanty few that will give practical and satisfactory results. Even these traps must be carefully selected for the service conditions if satisfactory operation is expected. Would any engineer use a pet-cock where he knows a 3-in. valve should be installed? Of course not, but that is about what happens in the selection of steam traps. The trap may have an insufficient valve area or be of the wrong type or style, or the connections are not made right, or the installation may have all of these evils combined. Such conditions are not exceptional; in fact, they are the most common.

Of the four well-known types, including the tilting, expansion, bucket and float traps, each has a legitimate function under certain conditions. The writer has used all four types with success, because each was carefully selected for the particular work in hand. When in doubt as to the trap best suited for the conditions the float type trap has been relied upon because the drainage and discharge of condensate is continuous. The float trap with the Corliss valve movement has given the best results. It is a very simple and rugged affair, and has only one moving part in the form of its combined float and valve.

The general ignorance as to what a trap is, and what it should do, is often responsible for many troubles that the engineer finds in his plant. Why, even "experts" seem to know mighty little on this simple subject, as the following will indicate:

On a big job recently completed there was a tremendous amount of piping, in which "all kinds" of steam flowed, serving various purposes, such as heating equipment, drying and cooking apparatus, pumps, engines, as well as general high and low pressure service. This means the use of more than 1000 traps. Different styles as well as makes of traps were purchased, because no one could supply them all at once. This led to the use of some traps that immediately gave trouble, because they were not suited to the conditions, so they were discarded as junk. Of the other traps, both good and bad, some were connected into the piping system so that no one saw or cared how they functioned as long as the system appeared to be running smoothly; however, others of the same types were connected so they discharged into the open where they could be observed as well as heard. Though the system worked, considerable leakage and waste of steam was evident. But which style of trap was at fault?

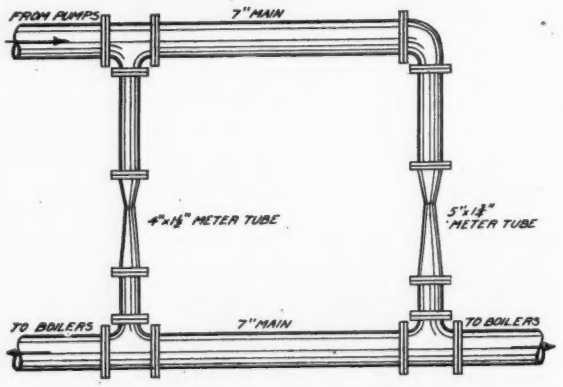
The "experts" in charge of the installation agreed with the "experts" in charge of operation that there was something wrong, and then decided that the traps which were continually discharging a nice stream of hot water were the cause of all the trouble. Asked for an explanation, they stated that the other style of traps discharged intermittently, and that they knew when the traps were working because the noise of the discharge could he heard. After an argument and practical demonstration, these "experts" were finally convinced by one of the "cheap help" that they were entirely wrong. Result? Why, some of the noisy traps were taken off the line because they were unsuited for this condition.

The "Big Chief" later admitted that while he had handled hundreds of traps in his 30 yr. experience, he had never seen one type or another with an open discharge, and therefore thought the quiet continuous flow means a leak rather than actual drainage with the trap working efficiently. The real leaky traps were those operating intermittently and discharging steam as well as water, and proclaiming their waste with a roar.

J. WILMORE.

A Meter Suggestion

Two obsolete boiler houses, furnishing steam for separate departments of a mill, were to be razed to make way for a central, modernized installation of boilers and equipment capable of taking care of the mill's ever increasing load. Each old boiler house was equipped with a suitable feed-water meter.

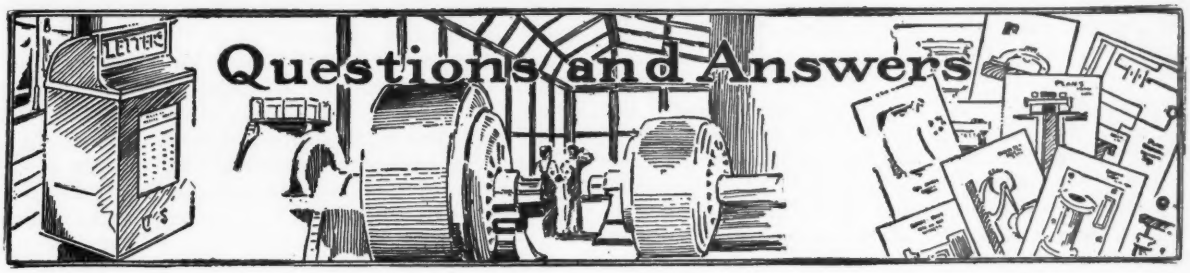


METERS CONNECTED IN PARALLEL

When the new plant was going up, some one realized that no provision had been made for a meter large enough to handle water for the new plant. Separately, neither of the meters then in use was of large enough capacity; it remained for the chief engineer to suggest that, rather than purchase a new meter, both the old ones could be used, as their combined capacity would be amply sufficient.

This was done as shown in the sketch, care being taken to insure large enough intake and discharge lines. The installation worked perfectly and thus the cost of a new meter was saved. NEW YORK.

MAKE YOUR money "work or fight." If it is not fighting for you in the industrial field, put it to work in War Savings Stamps.



Boiler Efficiency and Other Questions and Answers

ANALYSIS of coal used in a boiler trial gives the following result: Carbon 80 per cent; hydrogen 5 per cent; oxygen 4 per cent; nitrogen 2 per cent; and ash 9 per cent. Amount of coal used per hour was 4000 lb. There were 25,000 lb. of feed water at a temperature of 100 deg. F. evaporated into steam at 100 lb. absolute pressure. What is the efficiency of the boiler?

2. How is the water of condensation returned to the boiler in the one-pipe heating system?

3. In a double zigzag-riveted butt joint, with two cover plates, the pitch of the rivets is 4⅛ in. The rivet holes are 15/16 in. in diameter and the plate is ¾ in. thick. If the ultimate tensile strength of the plate is 58,000 lb. and the shearing strength of the rivets 40,000 lb., what is the efficiency of the joint?

4. What is the meaning of the term coulomb?

G. Z.

ANSWERS

IN ADDITION to the information which you have given, we should have the heat value of the coal which was used during the test, as no formulas have as yet been devised which will give this information, with satisfactory results, from the analysis of coal. In calculating boiler efficiency, therefore, we have used Dulong's formula, which is as accurate as any, and gives as the heat value of your coal 14,500 B.t.u. per pound.

You state that the number of pounds of feed water evaporated was 25,000, and the coal used was 4000 lb. This gives an evaporation of 6.25 lb. of water per pound of coal. With this information at hand, we turn to page 451 of the May 15 issue, and by means of the chart, we have calculated your boiler efficiency to be 48 per cent. Full explanation of the use of the chart is given on page 450, so that you can use the formula for finding your efficiency, if you so desire.

It appears, however, that the heat value of the coal as given by Dulong's formula, 14,500, is considerably higher than you are likely to be using. If this is the case, the efficiency would, of course, be higher than is given above.

2. In the single-pipe system of steam heating, the condensate returns to the boiler through the same pipe that carries the steam to the radiator. It is necessary, therefore, to have the pipe so arranged as to drain back to the boiler, and to have the pipe of sufficient size so that the condensate does not interfere with the flow of steam to the radiators.

3. To calculate the efficiency of the boiler joint, it is necessary to know the exact arrangement of the rivets and plates. We assume that what you mean by a double zigzag-riveted butt joint is what is termed the butt and double strap joint, double riveted.

As you know, the efficiency of a joint is the ratio of the strength of a unit length of riveted joint to the same unit length of solid plate. The strength of the solid plate is equal to the pitch, in inches, times the thickness, in inches, times the tensile strength. In your case this becomes:

$$4\tfrac{1}{8} \times \tfrac{3}{4} \times 58{,}000 = 180{,}000.$$

Now, to get the strength of the riveted joint, there are several factors which must be considered. First, we must compare the strength of the plate between rivet holes in the outer row to that of the solid plate. This is equal to the (pitch minus the diameter of the rivet hole) times the thickness, in inches, times the tensile strength; which in your case becomes:

$$(4\tfrac{1}{8} - 15/16)\ \tfrac{3}{4} \times 58{,}000 = 138{,}000.$$

Now, if this factor is the weakest, the efficiency of your joint would be, $138{,}000 \div 180{,}000 = 77$ per cent.

We have not, however, considered the strength of the rivets, and in this type of joint this is equal to the shearing strength of two rivets in double shear plus the shearing strength of one rivet in single shear, which in figures is equal to

$$2 \times 76{,}000 \times 0.69 + 1 \times 40{,}000 \times 0.69 = 132{,}480$$

Comparing this to the strength of the solid plate, we find that the efficiency would be 73.5 per cent.

Other factors which sometimes enter into the calculation, but are usually greater than those already considered, therefore do not decrease the efficiency of the joint, are: The strength of the plate between rivet holes in the second row plus the shearing strength of one rivet in single shear in the outer row, which is equal to the pitch minus (2 times the diameter of the rivet) times the thickness of the plate, in inches, times the tensile strength, plus the number of rivets in single shear, times the strength of the rivet in single shear, times the area of the rivet.

The second factor is the strength of the plate between rivet holes in the second row plus the crushing strength of butt strap in front of one rivet in the outer row, which is equal to (pitch minus 2 times the diameter of the rivet) times the thickness of the plate, times the tensile strength, plus the diameter of the rivet, times thickness of butt strap, in inches, times crushing strength of mild steel.

The third factor is, the crushing strength of plate in front of two rivets, plus the crushing strength of butt strap in front of one rivet, which is equal to the number of rivets in double shear times the diameter of the rivet, times the thickness of the plate, times crushing strength of mild steel, plus number of rivets in single

shear, times the diameter of the rivet, times the thickness of the butt strap, times the crushing strength of mild steel.

The fourth factor is, the crushing strength of plate in front of two rivets plus the shearing strength of one rivet in single shear, which is equal to the number of rivets in double shear times the diameter of the rivet, times the thickness of the plate, times the crushing strength of mild steel, plus the number of rivets in single shear, times the strength of the rivet in single shear, times the area of the rivet.

The results given by any one of the above factors divided by the strength of the solid plate will be the efficiency of the joint for that particular factor. The one which gives the lowest result is considered the efficiency of the entire joint.

4. The coulomb is the quantity of electricity transferred by a current of 1 amp. in one second. Another term for quantity of electricity, and one which is more commonly used, is the ampere-hour.

Adjustment of Automatic Engines

How may I adjust the automatic governor (Shepard type) of a 4-valve Erie City engine? Any information you may be able to give me will be greatly appreciated. M. L.

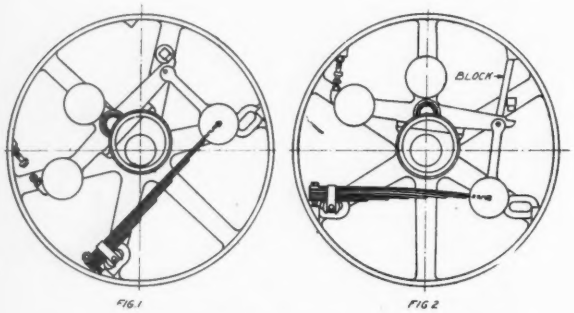


FIG. 1. GOVERNOR ECCENTRIC IN MID-POSITION

FIG. 2. GOVERNOR BLOCKED OUT TO SMALL TRAVEL-VALVES TO ADMIT NO STEAM WITH GOVERNOR IN THIS POSITION

A. First, see that the valve, valve seat and pressure plate are in good condition and not leaking. The pressure plate must be in proper position and its recesses must correspond exactly with the ports in valve seat. A leaky valve will cause the engine to run away, and if the pressure plate is not in proper position the effect will be the same. If you find that the above parts are in good shape and that the engine still jumps, start at the governor and examine the roller bearings. The rollers sometimes become stuck, causing the engine to race. Wash out the bearings thoroughly with kerosene and pack with vaseline. See that the inertia bar is moving freely on pin. The roller bearing should be filled with rollers of suitable size, and if a small space is left, it should be filled out with a smaller roller. This will prevent cramping of rollers and jerking of eccentric rod. When it is necessary to take inertia bar off from roller bearing, tie rollers with string as soon as inertia bar is partly off bearing.

If you find it necessary to set governor and valve motion, proceed as follows:

Put governor eccentric in mid travel (see Fig. 1) and give valve equal lap on each end. After this is done, block governor out to short travel (see Fig. 2), which gives the valve a motion of twice the lap. Then adjust valve until there is no lead, or, in other words, valve is to admit no steam to cylinder while governor is in this position. Test this by turning engine around for a couple of times.

Place exhaust rocker arm in center of travel by putting the rocker pin in vertical line with pivot pin; then adjust lap on valves as follows:

Crank end to over lap ⅛ in.—head end to have ⅛ in. clearance. Move crosshead to about 2 in. from end of stroke and turn eccentric around on the shaft to get above openings.

Take out blocks; closeup steam chest; start engine, and screw down nut on spring stud until you get the speed wanted. Then attach indicator and take cards with governor controlling. If you find that the crank end of the card is not as high as the head end of the card (see Fig. 3), and if the cutoff is earlier on the crank end than on the head end, add weight to the weight arm. If it is found that the head end is lower than the crank end (see Fig. 4) and the cutoff is earlier, add

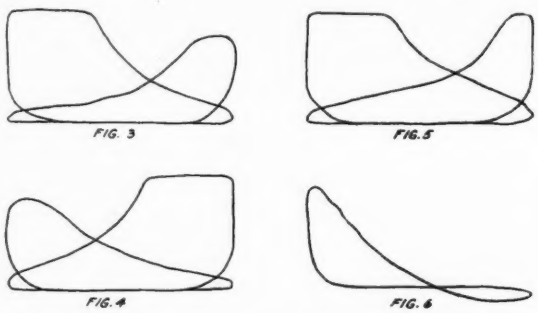


FIG. 3. CRANK END OF CARD LOWER THAN HEAD END

FIG. 4. HEAD END OF CARD LOWER THAN CRANK END

FIG. 5. BOTH CARDS OF LIKE HEIGHT

FIG. 6. WHEN THIS KIND OF DIAGRAM IS OBTAINED, SHIM ECCENTRIC

weight to the inertia bar. If it is found that both cards are of the same height (see Fig. 5) but that the cutoff is different, adjust valve at normal load. If a diagram is obtained (as Fig. 6) shim the eccentric.

Erie City Iron Works.

Cold Storage Piping and Insulation

My company is contemplating the erecting of an ice house, for storage, 36 by 36 ft., with 18-in walls, to be built of concrete and brick, and as near fireproof as possible. Ceiling is to be 20 ft. high, and one cold storage room will be possible in the basement.

Will you please give me all the information you can as to the latest and best insulation for the foregoing. also the number of feet of 2-in. pipe, direct expansion. it will require for proper refrigeration when well insulated? J. W. W.

A. Where the temperature of cold storage rooms is to be kept at from 32 to 10 deg. F., current practice

requires one running foot of 2-in. pipe for each 10 cu. ft. of space. The storage house which you propose to erect has overall dimensions of 36 by 36 ft., with a head room of 8 ft. This would provide a cubical contents of 36 by 36 by 8, or 10,368 cu. ft.

If, therefore, you are to provide one running foot of 2-in. piping for each 10 cu. ft. of space you will require 10,368 divided by 10, or 1036 running feet with this size of piping.

As to the insulation which you propose to employ in connection with this cold storage room, we might suggest the use of two layers of 4-in. insulation directly against the walls. One course of this should be 2-in. cork board (all cork) and erected on a ½-in. bed of Portland cement mortar, mixed in the proportion of one part Portland cement to two parts of clean cut, sharp sand, all vertical joints being broken. The second course should also be of 2-in. cork placed against the first in a ½-in. bed of Portland cement mortar, and additionally secured to the first with galvanized wire nails. All joints for the second course should be broken in respect to all joints in the first course, and special care must be taken to make such joints as tight as possible.

After these two layers of cork board have been applied, the whole should be covered with the Portland cement plaster.

Economizer Operation Questions

WE HAVE at our plant an economizer and I should very much like to obtain some information regarding its care and operation.

How often should the blowoff be opened?

2. What is the lowest temperature at which it would be safe to deliver feed water to an economizer?

3. How frequently should pipes and headers be washed out?

4. What is the best method to employ to get the returns from heating coils, slashers, etc., back into the boilers, by using a tank return pump or by using a return trap?

Which would waste the least steam, the pump or the trap?

Would you return the water to the boiler through the feed pipe, or the blowoff, or would you employ a separate line? E. E. A.

ANSWERS

IN REGARD to your questions on economizer practice, the blowoff on the economizer should be opened every one or two days, depending on how much precipitate is found in the bottom of the tubes. This should never be allowed to accumulate to any great depth.

2. The lowest temperature at which feed water can be introduced in the economizer without producing sweating which will be troublesome, is 90 deg. F.

3. As to the washing out of the pipes and headers, this should be done two or three times a year, depending on the accumulations found. This will, all, of course, vary with the condition of the water as it comes to the economizer. If it has been passed through an open feed water heater, where it has had a chance to become heated up to, say, 190 deg. F. and to deposit a considerable part of its solid matter, there will be but little deposit in the economizer. On the other hand, if you use a closed heater, and the temperature of the water is 90 to 100 deg. F. as it comes to the economizer, there will be a considerable deposit, and the blowing down and washing out will have to be more frequent.

4. In regard to getting returns back to the boiler, whether to use a pump or a return trap depends upon the arrangement of the plant, the amount of water to be handled, and the distance that it is to be carried.

The water will come from the returns by gravity, and if it is to flow to a point below the boiler water level, as is usually the case, it will be necessary to use two return traps—one to lift the water up above the water level, the other to force it into the boiler. If there is a large amount of water to be handled, this will mean a considerable investment in traps, whereas a single pump will take the water from the return tank and force it into the boiler.

So far as economy is concerned, probably the trap wastes less steam, as whatever steam the trap uses is forced back into the boiler with the returns, and the only lost heat is from radiation. With the pump, the exhaust steam can be used for heating feed water in either open or closed heater, or the exhaust from the pump can be sent into the heating system. In that case, there would be no loss of steam from the exhaust of the pump.

Our preference would be to return this condensation from the heating coils through the regular feed pipe into the boiler. Feeding through the blowoff is not usually considered good practice. It forces the sediment away from the blowoff, whereas the ideal condition would be to have the sediment and precipitates settle as near to the blowoff as possible, so that, in blowing down, this matter will be carried out of the boiler.

There is no need of having a separate pipe enter the boiler for the condensation from the returns.

Cooling Tower For Ice Plant

I AM OPERATING an ice plant and the water we are using, taken from a deep well, is causing the formation of much scale in our boilers. I have suggested the installation of a cooling tower, by means of which we could re-use our water indefinitely, adding only a small percentage from our well for make-up. This scheme I believe would at least in part overcome our trouble.

Will some of the readers advance an opinion as to whether they think this will work or not? E. L. A.

Placing Locomotive Tires

CAN some one of the readers of Power Plant Engineering tell me how or by what means I might remove and place locomotive tires? I have nothing but an ordinary machine shop available and would greatly appreciate any information along this line. G. W. M.

Correction Notice

ON PAGE 425 of the May 1 issue, I discovered an error in the problem for calculating the safe working pressure of a boiler according to the Massachusetts formula. The product of 2, 58,000, 0.375 and 0.82 is divided by the product of 5 and 50 and a quotient of 115 lb. given as the safe working pressure. This is incorrect and should be 140 lb. A. D. PALMER.

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The Inductor Plant For Economy

Cost of labor in the generation of electric energy, as in all other forms of manufacture and production, has reached an unprecedented level, with the result that the price of the commodity has risen correspondingly. In general, however, but little relief can be expected through a reduction in the number of men comprising the plant personnel, for the possible detrimental effect upon the overall economy and the crippling of the service which may result would not allow such a procedure.

In steam plants, in particular, but little can be done either in original design or ultimate operation to remove this burden, other, perhaps, than the interconnection of such plants, especially so when working in conjunction with hydro-electric stations. Where such is the case, the steam station may be held in reserve for emergency service only and by means of foresight on the part of the engineer in charge of the design of the hydraulic plants, the item of labor costs may be kept down to a minimum. That this is possible is well borne out by the case of the interconnected systems of California, where, in addition to maintaining a high load factor (and therefore a minimum labor cost per unit output), a number of inductor generator plants are operated. No attendants are employed, low heads and small amounts of water otherwise wasted are utilized and, due to the characteristics of the type of machine and the installation, governors, exciters, field rheostats and other auxiliaries are eliminated, together with their consequent troubles and attendance.

It is obvious that this scheme cannot be employed in all localities; but wherever an appreciable head of water exists, investigation may warrant the installation of a small inductor generator station, whether for use in conjunction with an extensive central station system or as an auxiliary to an industrial steam plant. In either event, by the saving in fuel and labor bound to be realized, the investment should within a short time pay for itself.

Where used in connection with an independent steam plant, the labor saving item may not be the dominating factor; here the saving of fuel would undoubtedly be of greater importance, while where tied in with a network of transmission lines, a number of such inductor generator plants should be instrumental in bringing about a decided reduction in both labor and fuel charges.

Vacation Days

When the heat of the summer is at its highest and one gets no relief from the oven-like temperature of the engine and boiler rooms during the off hours of the complete day, the thoughts of a cool swimming pool with perhaps a fallen tree to jump off from and a fish hook and line and necessary can of bait come almost irresistibly to mind. It is probably the desire to do as we please and the sports of the days when we were allowed to do that very thing—most of the time—that bring these thoughts to mind. No matter what the cause, the thoughts will come and we are the better for letting them have full sway for at least a few days each year.

Those days that we recall are the days in which we dreamed of our future career and laid our plans for reaching the goal of our ambitions. It is a good thing

to review those plans once in a while, and there is no better place than where they were first thought out and no surer way than to occupy ourselves as we did then, for almost never are these plans put into writing for reference. To most of us that is a real vacation.

During the war an extensive study was made in England of the value of rest periods during working hours. They were found to be of greater value in some lines of work than others, but, as far as reported, every industry was benefited by establishing certain periods for relaxation from continuous work. These must be considered as relaxation periods and not periods for recuperation, the upbuilding of the body and nerve cells. This must take place at another time, which is at night or during time off—vacations.

The work of the engineer in a modern power plant is mostly mental—there is little of it that he does by reflex action or subconsciously. It is therefore brain rest that he requires, and to get this kind of rest he must change the line of his thoughts for a time; get away from himself; be another person for a time; be the boy in the swimming pool, or the fisher landing a three-pounder.

We are given one body and one mind—nobody has more—and the use we make of our personal being determines success or failure for us. Just as a turbine or boiler needs overhauling occasionally, the engineer needs recuperation—must have it in some form or another, or the blowup will surely come, with an expense far in excess of any vacation one is likely to plan. Cost what it must, let's put the "plant" up for needed repairs.

Readjustment of Industrial Employment

Changes are taking place so rapidly in the readjustment of working conditions that it is difficult to determine what will be the ultimate outcome. That workers are endeavoring to secure more voice in the management of industries with which they are connected is evident. To what extent this will be given cannot be stated. Many industries have experimented with joint boards, workmen's councils and other governing bodies with varied success. In the efforts of Power Plant Engineering to place before readers the most authentic information in regard to the agencies at work on this problem in the United States, we secured from F. C. Henderschott, managing director of the National Association of Corporation Schools, a statement in regard to the work of that association, which is studying the problem of a more equitable distribution of created wealth, through industrial pursuits, and also attempting to eliminate present wastes due to lockouts, strikes and other forms of industrial strife through scientific employment, training of industrial workers and other personnel problems. The following information is taken from this statement.

A recent inquiry among several hundred industrial corporations reveals that there are three plans that are being used, all designed to give employes more voice in management, especially as relates to working conditions, hours and wages. The results of the inquiry indicate that a considerable majority of the larger industrial institutions have either inaugurated some one of the three plans or are studying the various plans and gathering data on results so far obtained, with a view to determining which of the plans they will inaugurate. The plans are known as the "Works' Committee" plan, the "Industrial Council" plan and the "House and Senate" plan. The purposes of the three plans are practically the same, but the methods of operation differ. As far as known, none of these plans involve direct representation on the part of the workers on the board of directors. However, it is anticipated, if it is found as a result of experiments that employes assume the responsibility, which logically they must assume if they are to have a continuing voice in management, that ultimately employes will be permitted to name a minority representation upon the board. Such action probably will occur only in industrial institutions where a considerable number of employes are stockholders, and the representation which they secure upon the board of directors will be dependent upon the amount of shares of stock represented by the employes who have a right to vote for such representation.

Whether or not the representatives of the workers in industrial councils will assume a fair portion of responsibility remains to be determined. So long as shorter hours and higher wages can be secured through strikes, it is probable that the new co-operative plans will make slow progress, but when the time arrives, as it inevitably must arrive, that strikes are no longer successful, and when the public will demand to be heard in the settlement of wage disputes, it is believed that more constructive progress can be made in the working out of co-operative management and that the workers will then assume a more definite responsibility for production. It is obvious that responsibility must be assumed by the workers if the industries of the United States are to be placed upon a more democratic or co-operative basis. Efforts to introduce better training systems and more scientific employment methods are meeting with no opposition and are progressing steadily.

The survey also disclosed that plans to insure stock ownership by employes in the company by which they are employed are rapidly becoming installed, the number of companies now installing this feature being far in excess of the number that were working on similar plans prior to the reconstruction period. Stock ownership plans almost invariably include provision for service annuities or retirement pensions.

The belief expressed by Judge Gary, Chairman of the United States Steel Corporation, that efforts to unionize the employes of the various subsidiary companies of that corporation would not succeed because the men realize they are better off under "open shop" conditions than they would be under the control of unions, is assumed by many other industrial executives. In fact, the present effort is not only to secure employe or co-operative effort in management, with proportionate responsibility, but also to provide conditions whereby the workers of the larger industrial institutions will receive a greater degree of advantage than would be possible under the unions' control and direction.

The crux of the situation seems to be acceptance of responsibility by the representatives of the workers for greater output commensurate with shorter hours and higher wages.

N. A. S. E. Convention at Springfield, Mass.

THE 1919 convention of the New England branch of the National Association of Stationary Engineers was held conjointly with the annual exhibition and convention of the New England Association of Commercial Engineers at Springfield, Massachusetts, on July 8, 9, 10 and 11. The exercises of the convention and the display and demonstration of power plant machinery accessories and supplies took place in the Municipal Auditorium Building.

The convention opened on Tuesday evening, with all the booths in the large basement hall of the building filled with a splendid display of power plant and manufacturers' supplies.

The formal opening exercises of the convention took place in the greater hall of the building and consisted of commendably brief but interesting addresses and excellently rendered musical selections by an orchestra. In the unavoidable absence of the mayor, the function of welcoming the delegates was performed by Adolph W. Gilbert, president of the Chapman Valve Manufacturing Co., of Springfield. Mr. Gilbert spoke with discriminating appreciation of the intelligence, faithfulness and dependability of the engineers, of the important place filled by them in the industrial life of the nation, and he dwelt particularly on the great service rendered by them during the great war.

Mr. Gilbert spoke with the customary force, directness and clarity characteristic of the successful American business man, and at the close of his address was warmly applauded.

Andrew Waite, of Portland, Maine, president of the New England Engineers, followed with a well rounded and appropriate response to the welcome extended by the Springfield representative and thanked the city and the Chamber of Commerce for the very friendly and hospitable spirit manifested toward the delegates, which, however, was but a repetition of past experience and would long be pleasantly remembered. He recounted briefly the character and purpose of the engineers' organization and dwelt with pride on the fact that no taint of Bolshevism could attach to its members, all of whom must be American citizens or have made formal application for citizenship.

Albert P. Langtry, Massachusetts Secretary of State, made a patriotic and stirring address in the course of which he indignantly denounced Bolshevist principles and practices.

Addresses brief in extent but replete with pertinent facts and practical suggestions were made by A. W. Pettie, of the Commercial Engineers; Joseph Eccleston, past president; W. J. Reynolds, Major J. W. H. Myrick, and B. L. Ames.

At the business session of the N. A. S. E. Convention, officers were elected and many important matters dealt with. Reports were made by the various standing committees and officers, and were received and accepted with approval. That of Treasurer Walter H. Damon indicated an excellent showing made of the Association's financial condition. The following officers were elected to serve for the ensuing year; President, Warren H. Goodrich, of Bridgeport, Conn.; vice-president, Elmer Dean, of Springfield; secretary, Freeman L. Tyler, of Taunton; treasurer, Walter H. Damon, of Springfield, re-elected; conductor, John R. Graham, of Fall River; doorkeeper, Charles Wlef, of New Bedford. Mr. Damon, who has for a long time been one of the prime movers in the New England Association, was elected to his 17th term of office.

DELEGATES AND FRIENDS AT THE CONVENTION OF THE NEW ENGLAND ASSOCIATION OF STATIONARY ENGINEERS

Following the election, the officers were installed by Past National President W. J. Reynolds, of Hoboken, N. J., assisted by Past National President Herbert Kelsey and Past President Joseph Eccleston.

The convention voted to hold next year's convention at Worcester.

The Commercial Engineers also held their annual election of officers and elected and installed the following well-known and efficient gentlemen to manage the affairs of the organization for the ensuing year:

President, Harry A. Atkinson, of Charlestown; vice-president, L. A. H. Merihew, of Boston; treasurer, James

W. H. Myrick, of Boston; directors for three years, Charles F. Ceilley, of New York; William D. Naughton, of Boston, and Adelbert W. Pettie, of Boston. This organization will also hold its 1920 convention in Worcester, in connection with that of the stationary engineers.

The efficiency of the committee in charge of the preliminary arrangements for the convention which was manifested in the completeness of the business features extended also to the provisions made for the entertainment of delegates and guests. On two evenings there was dancing in the "Mahogany Room." On Friday evening an entertainment was given in the great auditorium hall. The first number of the program was an organ recital by Arthur Turner. It was followed by a stage program of songs, dances, acrobatic performance and recitations, some of which were by professional artists and all of which were in merit above the average of what is offered on the professional stage.

On Saturday morning the delegates and the ladies were treated to an automobile tour of Springfield, and at 11 o'clock the boat was taken on the Connecticut to Riverside Park, where the rest of the day was spent in field sports, a ball game and a clambake.

It is agreed on all hands that the credit for the exceptional success of the convention was mainly due to the foresight and indefatigable efforts of the committee in charge, consisting of Walter H. Damon, chairman; Elmer L. Dean, Frank H. Dearden. Exhibition Committee: Claud D. Allen, chairman; Bradford L. Ames, Clarence L. Eggleston, Jr., Frank Bulkley, John H. Harrington.

The Lunkenheimer Co. to Build New Plant

THE Lunkenheimer Company, Cincinnati, has announced its intention greatly to increase and improve its manufacturing facilities by building a complete new plant. The site selected for the undertaking comprises about 70 acres of land in Carthage, a suburb of the City of Cincinnati, directly on the Toledo Division of the Baltimore and Ohio Southwestern Railroad. The location selected is not far distant from the center of the city, and is in the heart of one of the manufacturing sections of the city, where labor is plentiful and facilities for the handling of incoming and outgoing freight are ideal.

Plans for the erection of the new buildings are being prepared by capable engineers, and it is expected that work on the new structures will be started within the next few months.

Buildings will be of the one, two, and three-story types, of steel and concrete construction, and there will be provided all modern devices for the manufacture, handling, and transportation of raw materials, part finished and finished products. The undertaking will represent an outlay of approximately $2,000,000.

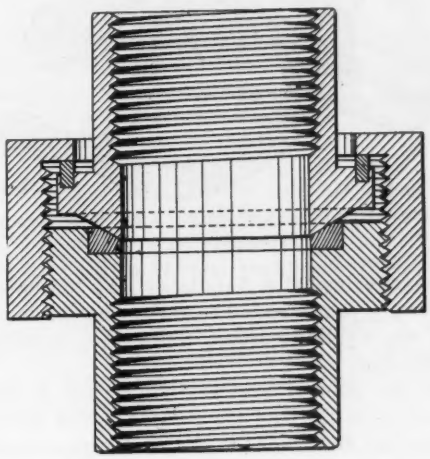
The welfare of the employes has been given special consideration. A piece of land about eight acres, lying directly opposite the land upon which the main plant is to be located, has been reserved as a recreation center, upon which will be erected an assembly hall, club rooms, baseball grounds, tennis courts, swimming pool, etc. Upon this site will also be erected a dining room capable of accommodating 1000 employes at one time.

The Lunkenheimer Co. moved to its present location in North Fairmount, Cincinnati, about the year 1900, the plant then comprising two manufacturing buildings, since which time many additional buildings have been erected. Having outgrown its present plant, being sorely in need of additional manufacturing facilities, and there being no more property available in the North Fairmount section, the company determined that the best plan was to acquire acreage property, with a view to providing for the future, as well as present, necessary expansion. The new plant, when completed, will contain about three times as much floor space as now used by the company.

Arrangements are being made so that there will be no interruption to the business of the company while the building operations are in progress, nor while the task of moving into the new plant is under way.

The Codd Pipe Coupling

IN the Codd pipe coupling or union, a section view of which is shown herewith, elimination of leakage is insured by the use of a stationary soft metal seat between the opposing faces of the sections of the coupling in addition to the regular soft metal seat at the juncture of the two sections.



SECTION OF THE CODD PIPE COUPLING

The washer fitted into a recess at the inner end of the female section of the coupling is of some suitable soft metal, such as brass or copper, and is provided with an inclined or beveled face so as to form a tight joint with inwardly inclined face of the inner end of the male member. This, as shown, is also fitted with a soft metal washer which is secured in place by means of a groove and bears against the inner face of the nut.

It is thus evident that, should for any reason a leak occur along either of these seats, escape of the fluid being conducted will be prevented by the other joint.

THE ENGINEER will not be picked from his profession to serve in public life. He must himself show social and public activity.

A New Lead-Burning Transformer

THE MOST modern method of burning storage battery terminals, removing old connections, cutting off or building up posts, or in fact almost any form of lead work, is to do it electrically—by the electric welding process.

A lead-burning transformer to meet this need has recently been developed. This transformer is designed to be connected to the ordinary 110-v. alternating-current lamp socket, a 10-ft. cord with plug being provided for this purpose. This attaching cord is protected by a special rubber covering against the hard wear, dirt and acid with which it may come in contact. Connection to the transformer itself is made by means of a plug and socket connection so that this plug can be used in place of the snap-switch in the lamp socket for turning the current on and off.

Two separate rubber covered terminal leads are used to convey the low voltage heat producing current to the parts of the battery to be welded. The lead having the "Big Brute" clip is for fastening to the battery plate or post which is to be worked on, while the other lead has at its end a carbon holder which is arranged

THE LEAD-BURNING TRANSFORMER AND THE METHOD OF APPLICATION

with a heavily insulated handle so that the operator's hand is amply protected. The carbon holder takes any ordinary arc welding carbon, this carbon forming the second terminal.

When the pointed arc welding carbon is brought into contact with the lead the pointed end of the carbon becomes so hot that it melts the lead over a restricted area quicker than will a pointed gas flame. The welding or burning operation is carried out by a sort of puddling process, the carbon terminal being manipulated to flow the lead where it is needed.

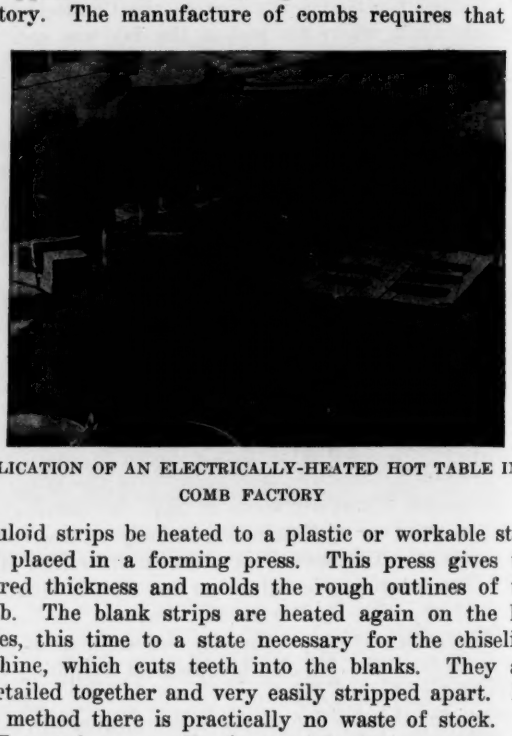
Among the advantages of the electric lead burner are that repair work in hard-to-get-at corners can be done more easily, as the heat is always right at the point of the carbon; the device is readily portable, weighing approximately 25 lb.; joints do not have to be cleaned, as the dirt and slag automatically rise to the surface of the molten lead and the surfaces are joined while cleansed; when properly used, there is no glare to injure the operator's eyes, as he looks down on the cool end of the carbon in such a way that the bright point where the carbon touches the lead is hidden from view. Because of efficient insulation, there is no danger from electric shock.

On the basis of 10 cents per kilowatt-hour, it costs about 8 cents per hour for current when the device is operating steadily. The instant the carbon point is removed from the work, the current consumption practically ceases, as the device then takes only 4½ w. from the line.

Owners of these transformers have found an increasing field of application. The device is said to be especially valuable to automobile owners in reconstructing and repairing batteries, while in the shop and foundry it has been used where all kinds of odd soldering jobs must be done. The device has also been found applicable in plumbing, roofing, tank building, etc.

Electrically Heated Hot Tables For Comb Making

THERE have been numerous applications of the electrically-heated hot table, but one of the most important and most successful in every respect is its application to the working of celluloid in a comb factory. The manufacture of combs requires that the



APPLICATION OF AN ELECTRICALLY-HEATED HOT TABLE IN A COMB FACTORY

celluloid strips be heated to a plastic or workable state and placed in a forming press. This press gives the desired thickness and molds the rough outlines of the comb. The blank strips are heated again on the hot tables, this time to a state necessary for the chiseling machine, which cuts teeth into the blanks. They are dovetailed together and very easily stripped apart. By this method there is practically no waste of stock.

For such an application certain temperatures are required, and, as can readily be seen, varying degrees of heat are necessary for the various steps in the process. The standard electrically-heated hot table has just such characteristics as are required in the comb industry. The tables, which are 16 by 24 in., are normally rated at 1800 w., 110 v. and equipped with a three-heat snap switch control. They have six 300-w. steel-clad heaters installed under the steel top plate, and the heaters are so connected as to give 1800 w. on high, 900 w. on medium and 450 w. on low, a range found very suitable for comb heating application.

At the Ideal Comb Co. plant in Lowell, Mass., with an initial installation of five electrically-heated hot tables, they increased their production about 20 per

cent. It was estimated that operating the tables constantly at medium heat with a short period in the morning and another at noon on high, it cost about 17c a day per table. The power rate in this territory is 10c for the first 20 kw.-hr. and 2c thereafter. Using this rate, they estimated it cost about 9c per day per table on the low heat. By changing from steam to electric heat it has been estimated that there will result a net saving of $100 per month on wages of firemen and on coal.

Due to the uniform heating of the electrically-heated hot tables, it was found possible to use 0.125 in. celluloid stock on the electric hot table, while 0.140 in. stock was the smallest possible with the steam table.

News Notes

CHARLES GILMAN HYDE, professor of sanitary engineering at the University of California, has been employed by the City of Sacramento as consulting engineer in the construction of a water filtration and pumping plant for which bonds to the amount of $1,800,000 were voted by the people in June, 1919.

The filtration plant at Sacramento is to be of the mechanical or rapid sand type, filtering the water of Sacramento River. Its nominal capacity will be 30,000,000 gal. a day, and sulphate of alumina will be used as the coagulant. This will be the first modern municipal filtration plant in California and is expected to be in operation early in 1921.

For more than 50 yr. Sacramento's water supply has been unfiltered and at times it has been turbid and muddy, so that it could hardly be used. The decision of the people to build a filtration plant was the result of recommendations made by Professor Hyde, George H. Wilhelm and Frank C. Miller in 1916, after they had made a diligent and exhaustive investigation of all possible sources of water supply for Sacramento.

THE FORTHCOMING National Exposition of Chemical Industries at the Coliseum and First Regiment Armory, Chicago, during the week of Sept. 22 to 27, inclusive, holds possibilities of as great benefit to American chemical industry as in the past during the war period when it contributed so directly to the firm establishment of a chemical industry in this country.

One feature of the coming exposition will be the number of electric furnace exhibits. The United States Bureau of Mines will have on exhibit about 30 metals showing the complete course of extraction from their ores, the various stages through which they pass and the materials used in their extraction. The mineral world and mineral utilization will come in for its share of recognition and will show that in the general advancement of the chemical industries it has taken no small part. Ceramics will be brought strongly to the front through exhibits of products and materials developed for specific purposes during the war period and just now permitted free display for the industries that can use them.

Among the numerous instruments, devices and apparatus that have been perfected during the intense war period for precise measurements of temperature, weights, volumes, velocities, flow of liquids, gases, solids, electric current and any and all kinds of commodities that are to be measured, their number is legion and they occupy no small space in this exposition.

The program of the exposition, the managers advise, as being arranged will be one of much interest. The meetings of the Societies which are meeting in conjunction with the exposition are scheduled for the following dates:

American Institute Mining & Metallurgical Engineers, Sept. 22-27.

American Ceramic Society, Sept. 24.

American Electrochemical Society, Sept. 24-26.

Technical Ass'n Pulp & Paper Industry, Sept. 24-27.

THE ENFORCEMENT of regulations governing the practice of surveying and civil engineering in Idaho now comes under the Commissioner of Law Enforcement, R. O. Jones, Boise, Idaho. There is now a law regulating the practice of civil engineering in Idaho which appears to include all branches except mining and metallurgy. Examination for civil engineers will be held the second Tuesday in September and that of surveyors the first Tuesday in September. No survey or plat of land has been legal since June 1, 1903, unless made by a licensed surveyor.

THE OREGON SOCIETY OF ENGINEERS unanimously voted at its meeting on July 24 to amalgamate with the American Association of Engineers. Other societies that expect to vote upon amalgamation in the near future are: The Engineers' Club of Kansas City, the Engineers' and Architects' Association of Southern California, the Southwestern Society of Engineers and the Houston Engineers' Club. The question of amalgamation has been initiated by several other societies and is now under consideration by them.

THOMAS O. MORGAN, until recently head of the Service Department of the New York Office of the American Steam Conveyor Corporation, has been promoted to the position of Sales Engineer. He will handle Long Island and Connecticut territory. Mr. Morgan's sound experience in service work has been a splendid training for his new responsibilities and his customers are assured of receiving authoritative advice on correct ash disposal engineering.

THERE HAS BEEN a long and insistent call from engineers in the East for the A. A. E. to open an office in New York. The Board of Directors wanted to be sure that the right man was found and is pleased to announce the employment of K. B. Knudsen. The temporary address of the New York Chapter will be 50 Church St., New York. Permanent address will be anuounced as soon as offices are selected.

ON JULY 9, the Navy Department increased the pay of its technical employes, effective July 1. The technical force of the Navy has been working for over 7 mo. to obtain a readjustment in compensation. Their case has been handled through special wage boards at the Navy Yards and a Department Board. The latter board finally abandoned the idea of a wage schedule after one month's work and simply recommended new rates of pay for each individual member of the technical force. This Depart-

mental Board considered that a general reclassification of these employes under a limited number of rates was not feasible and any attempt at a reclassification would result in readjustment of rates and pays not in accordance with the relative merits of the individuals and would be a source of discontent among those affected. This decision was rendered in spite of the fact that the Navy Yard boards submitted definite wage schedules and classifications.

THE ASHTON VALVE CO. has appointed Wm. J. Neville, Candler Bldg., Atlanta, Ga., as Southern District Sales Manager, covering the following states, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisiana, Arkansas, Tennessee.

ANNOUNCEMENT is made of the removal of the Minneapolis office of the Chicago Pneumatic Tool Co. from the Metropolitan Bank Building to Fifth Avenue and Fifth Street, South, where a complete stock will be maintained.

THE ENGINEERS' Society of Western Pennsylvania recently made an inspection trip to the feed water treating and purifying plant of the Republic Steel & Iron Co. at Youngstown, O. There were 275 engineers present and following the inspection a dinner was served at the Hotel Ohio, the host being Wm. B. Scaife & Sons Co., who installed the plant.

R. SANFORD RILEY, president of the Sanford Riley Stoker Co. and the Murphy Iron Works, sailed for Europe on July 26, aboard the Aquitania. Before his departure Mr. Riley was appointed Honorary Vice-President of the A. S. M. E. He will represent the Society and this country at the James Watt Centennial which is to be held at Birmingham, England, on Aug. 25. Mr. Riley expects to return about Oct. 1.

COL. C. H CRAWFORD, until recently Assistant Superintendent of the Eddystone Plant of the Baldwin Locomotive Works at Philadelphia, has been transferred to South America as its Brazilian Manager, with office in Rio de Janiero. Mr. Crawford is a member of the National Board of Directors of the American Association of Engineers and will serve as representative of the Association in South America.

THE AMERICAN STEAM CONVEYOR CORPORATION has just announced the appointment of H. S. Valentine as Sales Engineer in charge of Philadelphia territory. An office has been established in the North American Building, Philadelphia. Mr. Valentine is an experienced mechanical engineer and was connected with the Link Belt Co, of Philadelphia, for 5½ yr., with the Brown Hoisting Machine Co. and Yale & Towne Mfg .Co. for 6 yr. and with the Badenhausen Co. for one year.

A. W. HOUSTON has resigned his position as vice-president and general manager of the Texas Gas & Electric Co. to accept a similar position with the Southern Utilities Co. Mr. Houston will have his headquarters in Palatka, Fla., and will have supervision of plants of the Southern Utilities Co., in the states of Florida and Georgia. H. F. Cameron of the Lake Charles Railway, Light & Power Co. has been appointed vice-president and general manager of the Texas Gas & Electric Co. and will have his headquarters in Houston, Texas. Both appointments became effective Aug. 1, 1919.

THE STEAM MOTORS CO., Springfield, Mass., announces that the Southern Engineering Co., 425 Gravier St., New Orleans, La., has been appointed representative of the company for the New Orleans territory.

CHARLES G. GUILD has been announced as successor to Clayton O. Griffin as secretary and service manager of the Wayne Oil Tank & Pump Co. The announcement comes as a culmination of Mr. Griffin's resignation.

Mr. Guild comes from the Burlington Wheel Co., of Burlington, Iowa, where he held the position of manager. He was formerly manager of the Jenny Electric Light and Power Co., of Fort Wayne, continuing with the General Electric Co. when a consolidation was perfected. In 1910 Mr. Guild accepted an offer from the Burlington Wheel Co. and left for Iowa to take up his new position there. The new official is recognized for his business ability, and his success as an official of the local company is assured.

AT A MEETING of the Board of Directors of the Wheeler Condenser & Engineering Co., Carteret, N. J., on July 8, J. J. Brown, formerly vice-president and general manager, was elected president, succeeding Charles W. Wheeler, recently deceased. H. S. Brown, of 50 Congress St., Boston, was elected vice-president. No other changes were made in the officers.

H. S. Brown has been associated with the Power Specialty Co. for the past 15 yr., the greater part of the time as New England manager for that company. During the war he was active with their government work with headquarters at Washington and Philadelphia. He is also president of the Brown-Ferries Co., of Philadelphia.

The business of the Wheeler Condenser & Engineering Co. has more than quadrupled during the past 10 yr. under the management of J. J. Brown, and the manufacturing capacity of the plant has been correspondingly increased.

U. S. CIVIL SERVICE COMMISSION announces open competitive examinations, Aug. 26, for Patent Investigator (male), $1200-$1800, and Expert Patent Investigator (male), $1800-$2400. Vacancies in the Patents Section, Purchase Branch of the Purchase, Storage, and Traffic Division, War Department, at the salaries indicated, and in positions requiring similar qualifications, at these or higher or lower salaries, will be filled from these examinations. Competitors will be rated on general education, technical training and experience. Applicants for patent investigator must have the equivalent of a 4-yr. high-school course and must have completed 1 yr. of a technical course in a college of recognized standing, or have been employed for 1 yr. in a position in which they required a knowledge of technics, or have completed 2 yr. of academic college work with special training in science and mathematics; they must also have had at least 2 yr. experience in Patent Office "searching." Expert patent investigator requires additional qualifications. Apply for Form 1312.